City of Renton
Shoreline Master Program

Final Shoreline Inventory and Analysis

Prepared for

City of Renton
City Hall
1055 S. Grady Way
Renton, Washington 98057

This report was funded in part through a grant from the Washington Department of Ecology.

Prepared by

Parametrix
411 108th Avenue NE, Suite 1800
Bellevue, WA 98004-5571
T. 425.458.6200 F. 425.458.6363
www.parametrix.com

ESA Adolfson
5309 Shilshole Avenue NW, Suite 200
Seattle, WA 98107
T. 206.789.9658 F. 206.789.9684

Maney ARC
1719 E. Spring Street Suite 301
Seattle, WA 98122
T. 206.383.2447

March 2010 | 553-1779-031 (04/0401)

CITATION

Parametrix. 2010. Shoreline Master Program Revised Draft Shoreline Inventory and Analysis. Prepared by Parametrix, Bellevue, Washington. March 2010.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

APPENDICES

Maps

ACRONYMS AND ABBREVIATIONS

BMP	best management practice
BNSF	Burlington Northern Santa Fe
BP	before present
BPA	Bonneville Power Administration
City	City of Renton
DAHP	Washington State Department of Archaeology and Historic Preservation
DDES	King County Department of Development and Environmental Services
DDT	dichloro-diphenyl-trichloroethane
DNR	Department of National Resources
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GMA	Growth Management Act
HCP	Habitat Conservation Plan
KCDD	King County Drainage District
LAAS	Larsen Anthropological Archaeology and Historic Preservation
LWD	large woody debris
NCDC	National Climate Data Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NWAA	Northwest Archaeological Associates
NWI	National Wetlands Inventory
OHWM	ordinary high water mark
PAA	Potential Annexation Area
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSBRT	Puget Sound Biological Review Team

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RCW	Revised Code of Washington
RM	river mile
RMC	Renton Municipal Code
ROW	right-of-way
SASSI	Salmon and Steelhead Stock Inventory
SMA	Shoreline Management Act
SMP	Shoreline Master Program
TMDL	total maximum daily load
UGA	Urban Growth Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WHR	Washington Historic Register
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

1.1 PURPOSE

The City of Renton (City) is conducting a comprehensive Shoreline Master Program (SMP) update with the assistance of a grant administered by the Washington State Department of Ecology (Ecology) (Shoreline Master Act [SMA] Grant No. G0800310). Cities and counties are required to update their SMPs to be consistent with the state SMA, Revised Code of Washington (RCW) 90.58 and its implementing guidelines, the Shoreline Management Guidelines, Washington Administrative Code (WAC) 173-26.

Early steps in the comprehensive SMP update process include the inventory and characterization of shoreline conditions. The inventory and characterization provide a basis for updating the City's goals, policies, and regulations for shoreline management. The term 'shorelines' in this report refers to areas that meet the criteria for 'shorelines of the state' as defined by the SMA (see Section 1.3 – Shoreline Jurisdiction and Definitions). As shown in Map 1a-e, the shorelines in the City are:

- Lake Washington
- May Creek
- Cedar River
- Green River
- Black River/Springbrook Creek
- Lake Desire, located in the City's potential annexation area.

Lake Washington is designated as a 'shoreline of statewide significance'. As such, additional policies apply to this shoreline since it is a statewide as well as local resource[1] (see Section 1.3 – Shoreline Jurisdiction and Definitions below).

This report describes the initial results of the shoreline inventory and characterization in accordance with Task 1.3 of the City's grant agreement with Ecology. It includes a general discussion of the ecosystem-wide processes that influence the City's shorelines and provides a detailed account of the ecological functions and land use patterns along each shoreline segment or reach.

This draft report will be revised and finalized based on comments from Ecology and the public. The final report will be used to guide other elements of the City's SMP update process including the development of shoreline policies, regulations, environment designations and restoration strategies.

1.2 REGULATORY OVERVIEW

Washington's SMA was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to growing concerns about the effects of unplanned and unregulated development on the state's shoreline resources. As a result, the

[1] RCW 90.58.030(2)(e)

central goal of the SMA is 'to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines'.[2]

The SMA is a joint state/local program. Local governments responsible for administration are charged with developing SMPs in accordance with state guidelines developed by Ecology. The guidelines give local governments discretion to adopt SMPs that reflect local circumstances and to develop other local regulatory and non-regulatory programs that relate to the goals of shoreline management.

The City developed its first SMP in January 1977. The most recent update was adopted in 2005 but has not yet been approved by Ecology. The SMP is maintained as a separate document that contains both policies and regulations. In addition, the regulations are codified in Title IV (RMC 4-3-090) of the Renton Municipal Code (RMC).

1.3 SHORELINE JURISDICTION AND DEFINITIONS

According to the SMA, the City's SMP regulations apply to all 'shorelines of statewide significance', 'shorelines', and their adjacent 'shorelands'[3]:

- 'Shorelines of statewide significance' include portions of Puget Sound and other marine water bodies, rivers west of the Cascade Range that have a mean annual flow of 1,000 cubic feet per second (cfs) or greater, rivers east of the Cascade Range that have a mean annual flow of 200 cfs or greater, and freshwater lakes with a surface area of 1,000 acres or more.
- 'Shorelines' are defined as streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area of 20 acres or greater.
- 'Shorelands' are defined as the upland area within 200 feet of the ordinary high water mark (OHWM) of any shoreline or shoreline of statewide significance; floodways and contiguous floodplain areas landward 200 feet from such floodways; and all associated wetlands and river deltas.
- 'Associated wetlands' means those wetlands that are in proximity to and either influence or are influenced by waters subject to the SMA4 (Figure 1-1). These are typically wetlands that physically extend into the shoreline jurisdiction, or wetlands that are functionally related to the shoreline jurisdiction through surface water connection and/or other factors.

In any given area, the landward extent of shoreline jurisdiction is identified based on site specific factors such as the location of the OHWM. However, for planning purposes, jurisdiction can be assumed to include the shorelands as generally depicted in Figure 1-1.

---

[2] RCW 90.58.020

[3] RCW 90.58.030

[4] WAC 173-22-030(1)

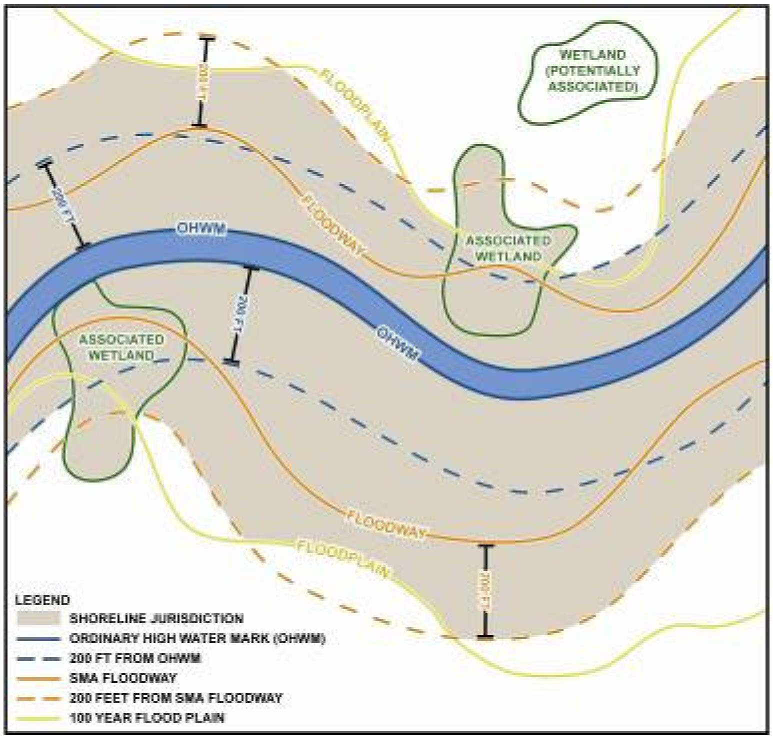

Figure 1-1. Graphic Depiction of the SMA Shoreline Jurisdiction

The City of Renton has identified three areas for potential annexation into the City: East Renton Plateau, Fairwood/Petrovitsky, and West Hill. If annexation occurs, all three of these Potential Annexation Areas (PAAs) would become part of the incorporated area under the City's jurisdiction. Shoreline areas are present in all three PAAs:

- The southwest corner of the East Renton Plateau PAA intersects a portion of the Cedar River.
- The Fairwood/Petrovitsky PAA, located south of the East Renton Plateau PAA, includes:
  - a section of the Cedar River
  - all of Lake Desire
- The West Hill PAA includes the shoreline of Lake Washington extending from the current Renton City limits to the Seattle City limits. It also extends to the current Tukwila City limits which includes land within 200 feet of the Green River (which lies immediately to the southwest).

The portions of Lake Washington, Cedar River, and Lake Desire that are located in Renton's PAA are included in this report. In addition, the area on the Lake Washington shoreline between the north City limits and the City of Bellevue is included in this assessment. This area is within the Urban Growth Area (UGA, as defined by the Washington Growth Management Act [GMA] of 1990[5]), but is not subject to a formal PAA agreement with

[5] RCW 36.70A

adjacent jurisdictions. The only access to this area is through the City of Renton and utilities are provided by the City. Thus, Renton is the jurisdiction most likely to annex this area in the future. The Shoreline Management Guidelines allow a city to pre-designate shoreline regulations within adopted UGAs.[6] Thus, adopted SMP regulations will be applicable to these areas upon annexation without requiring future amendment of the SMP (Map 1a-1e).

1.4 RELATIONSHIP TO OTHER PLANS

The City's SMP works in concert with the City's Comprehensive Plan and a variety of other regulatory plans and programs to manage shoreline resources and regulate development near the shoreline. The Comprehensive Plan and associated Sub-Area Plans establish the general land-use pattern providing an overall vision for growth and development for areas inside and outside shoreline jurisdiction. Various sections of the RMC pertaining to zoning (Title IV), environmental policy (4-3 RMC), stormwater management (4-6 RMC), and permitting (4-8 and 4-9 RMC) also play a major role in how the City's shorelines are managed.

The SMA requires local governments to review any plans, regulations, and ordinances that apply to areas adjacent to shoreline jurisdiction. Those plans, regulations, and ordinances need to 'achieve a consistent use policy' in conformance with the SMA and the SMP.[7] This means that the Comprehensive Plan and the development regulations of the City's municipal code must be consistent with the SMP.

One of the most important areas for consistency is between the SMP and 'environmentally critical areas' (4-3 RMC) development standards and use regulations. Environmentally critical areas including streams, wetlands, aquifer recharge areas, frequently flooded areas, fish and wildlife conservation, and geologic hazard areas are found throughout the City's shoreline jurisdiction. Although critical areas are to be identified and designated under the GMA, they must also be protected under SMA when located within the shoreline jurisdiction. The Washington State Legislature and the Growth Management Hearings Board have determined that local governments must adopt SMPs that protect critical areas within the shoreline at a level that is 'at least equal' to the level of protection provided by the local critical areas ordinance.[8]

The GMA also calls for coordination and consistency of comprehensive plans among local jurisdictions. Because SMP goals and policies are an element of the local comprehensive plan, the requirement for internal and intergovernmental plan consistency may be satisfied by watershed-wide or regional planning. Consistent with this provision, the City of Renton is coordinating with King County; the neighboring cities of Kent, Tukwila, Bellevue, Seattle, and Newcastle; and the Muckleshoot Indian Tribe during the SMP update process.

---

[6] WAC 173-26-150

[7] RCW 90.58.340

[8] Engrossed Substitute House Bill 1933

2. METHODS

2.1 DATA SOURCES

A number of local, regional, state and federal agency data sources, maps, and technical reports were reviewed to compile this inventory and characterization report. This includes information pertaining to watershed conditions and ecosystem-wide processes as well as data on the land-use patterns and ecological conditions of Renton's shorelines. Assessing conditions at these two distinct geographic scales, the watershed scale and the shoreline reach scale is a key requirement of the SMP update process.[9] A series of maps depicting shoreline and watershed attributes accompanies this report (as summarized in Table 2-1). Data sources from the King County Geographic Information System (GIS) database were used for the PAAs and the unincorporated area along Lake Washington, north of Renton city limits. A complete list of data sources used to compile the report is included in Section 6.

Table 2-1. Shoreline Map List

Map Title	Map No.
Shoreline Planning Area	1a – e
Regional Context	2
Water Bodies and Wetlands	3a
Topography, Water Bodies and Wetlands	3b
Landslide, Erosion and Seismic Hazard Areas	4a
Surficial Geology	4b
Critical Aquifer Recharge Area	4c
FEMA Floodplain	4d
Cedar River Floodplain	4e
Black River, Green River, Springbrook Creek Floodplain	4f
May Creek Floodplain	4g
Fish Distribution, Salmon Stock Inventory	5a
Fish Distribution, Salmon Rearing, Spawning	5b
Wildlife Heritage Points	5c
Shoreline Permits 2003-2009 City Wide	6
Shoreline Permits 2003-2009 Lake Washington	6a
Water Quality	7
Renton Comprehensive Land Use	8
Renton Zoning	8a
King County Zoning	8b
King County Comprehensive Land Use	8c
Impervious Surfaces	8d
Land Cover	8e
Impervious Surfaces (Roadways & Buildings)	8f
Transportation and Utilities	9a – d
Vacant Land Cover	10a - c
Shoreline Modifications	11a-h
Renton Parks and Trails	12a
Channel Mitigation Zones – May Creek	13a
Channel Mitigation Zones – Cedar River	13b

[9] WAC 173-26-201

2.2 DETERMINING SHORELINE PLANNING AREA BOUNDARIES

The approximate extent of shoreline jurisdiction within the municipal limits of the City and its designated PAA is shown in Map 1a, referred to as the 'shoreline planning area.' In general this extent represents:

- Lands within 200 feet of the mapped edges of Lake Washington within the City's municipal limits (Note: The mapped edge of Lake Washington is only marginally different than the OWHM);
- Lands within 200 feet of the mapped edges of Lake Washington within the designated PAA of the City;
- Lands within 200 feet of the mapped edges of Lake Washington within unincorporated King County, north of the City's municipal limits and south of Bellevue city limits;
- Lands within 200 feet of the mapped edges of Mainstem Cedar River within the City's municipal limits
- Lands within 200 feet of the mapped edges of Mainstem Cedar River within the designated PAA of the City;
- Lands within 200 feet of the mapped edges of Mainstem Green River within the City's municipal limits;
- Lands within 200 feet of the mapped edges of the Black River and Springbrook Creek within the City's municipal limits;
- Lands within 200 feet of the mapped edges of May Creek within the City's municipal limits;
- Lands within 200 feet of the mapped edges of Lake Desire within the designated PAA of the City;
- All floodways associated with the areas above; and
- Those portions of the 100-year floodplains currently mapped by the Federal Emergency Management Agency (FEMA) that are within 200 feet of the mapped floodway.

(Note: Lands within the floodplain of the Cedar River and Springbrook Creek within 200 feet of the floodway are only marginally different than lands within 200 feet of the OHWM in channelized portions of the river within the city. For Springbrook Creek, the floodplain for jurisdictional purposes is the floodplain of the creek itself and does not include portions of the Green River floodplain that overlap that of the creek.)

This area covers a total of approximately 14 linear miles within the City limits, 4 linear miles within the designated PAAs, and ½ of a linear mile in King County, outside the PAA. Of those, approximately 5 miles are along Lake Washington; 6 miles are along the Cedar River; less than ½ mile is along the Green River; 3 miles are along the Black River/Springbrook Creek; 1.6 miles are along May Creek; and 1.7 miles are along Lake Desire. The shoreline planning area encompasses approximately 900 acres.

Planning area boundaries were derived using existing information from the King County GIS database. The location of the 20 cfs flow point on streams was confirmed using best available information (U.S. Geological Survey [USGS], 1998).[10] For purposes of this report, the mapped edges of the lake and creek shorelines are assumed to correspond to the approximate

[10] USGS data regarding upstream boundaries for SMA streams and rivers (USGS, Water-Resources Investigations Report 96-4208) to confirm SMP jurisdictional boundaries.

location of the OHWM. Field inspection is required to identify the actual OHWM location on a specific property to determine jurisdiction limits, regulatory setbacks and/or buffers. Likewise, shoreline jurisdiction may include 'associated' wetlands. Generally, a wetland's relationship to the shoreline must be determined in the field by on-site inspection.[11] The maps outlined in Section 2.1 above indicate all mapped wetlands as potentially associated wetlands and likely include some wetlands that do not meet the criteria of "associated" wetlands.

The shoreline planning area is intended for planning purposes only. As a result, the actual regulated boundaries of shoreline jurisdiction may differ from the area shown on Map 1a, depending on information gathered on the ground at any specific location.

For purposes of the shoreline inventory and characterization, the shoreline planning area was divided into segments, called reaches. Reach designations were determined based on existing and potential land-use (e.g., residential, commercial, industrial land-use, parks, and open space). The Cedar River, Black River/Springbrook Creek, and May Creek are each divided into four reaches; the Green River includes one reach; and Lake Washington is divided into 11 reaches, including one in unincorporated King County and one in the City's PAA. The portion of Lake Desire in the City's PAA is designated as one reach. The extent and general description of individual shoreline reaches that comprise the City's shoreline planning area are summarized in Table 2-2.

Table 2-2. Shoreline Planning Area, City of Renton

Shoreline	Reach Numbers	General Description	Approximate Size (acres)[a]	Approximate Percentage of City's Shoreline (excluding PAA)
Cedar River	A through D	Extends from the mouth of the river to City limits at Ron Regis Park (along State Route 169)	405	45% (45%)
Green River	A	Within City limits (along West Valley Highway and east to the Black River pump station[12])	29	3% (3%)
Lake Washington	A through K	Extends from Bellevue to the West Hill PAA (between City limits and Seattle City limits)	132	15% (12%)
Black River / Springbrook Creek	A through C	Extends from the City limit on the Black River to SW 43rd Street (S 180th Street) at south City limit	203	23% (23%)
May Creek	A through D	Extends from the mouth (at confluence with Lake Washington) to Northeast 36th Street at City limits (Northeast portion of City)	91	10% (10%)
Lake Desire	A	Includes entire lakeshore except portion outside the City's PAA	41	5% (0%)

[a] Does not include open water areas; however, does include floodways, and floodplains within 200 feet of floodways based on existing mapping sources (see Map 1).

[11] Additional associated wetlands may be present that are not depicted on the available maps.

[12] This is designated as a Green River reach rather than a Black River reach because it primarily functions as a backwater of the Green River and is isolated hydraulically from the Black River by the pump station.

2.3 APPROACH TO CHARACTERIZING ECOSYSTEM-WIDE PROCESSES AND SHORELINE FUNCTIONS

SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes and their relationship to shoreline ecological functions.[13] Ecosystem processes generally refer to the dynamic physical and chemical interactions that form and maintain aquatic resources at the watershed scale. These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the watershed.

For this report, ecosystem processes were characterized using an approach similar to that described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al., 2005). The approach predicts water movement through a watershed based on topography, soils, geology, climate and other hydrogeologic factors. Across a watershed, these factors govern the patterns of surface water and groundwater flow between upland and aquatic areas. The approach focuses on water flow patterns because water movement underlies most of the other physical and chemical interactions that occur in a watershed.

The purposes of the ecosystem-scale analysis are to highlight the relationship between key processes and aquatic resource functions, and to describe the effects of land-use on those key processes. The goals are to:

- Identify and map areas in the watershed that are most important to processes that sustain shoreline resources;
- Determine the extent to which those important areas and their processes have been altered; and
- Identify management strategies and potential opportunities for protecting or restoring these areas.

The results of the analysis are provided in Sections 3.

2.4 APPROACH TO INVENTORY AND CHARACTERIZATION OF REGULATED SHORELINES

The inventory and characterization at the reach scale of the Cedar River, Green River, Lake Washington, Black River/Springbrook Creek, May Creek, and Lake Desire scale is intended to characterize conditions adjacent to each of the SMA-regulated water bodies as well as in-water conditions. .

A boat survey of the Lake Washington shoreline was conducted in the Renton city limits and PAAs on April 8, 2008. The shoreline survey extended from the Bellevue city limits on the east side of the Lake to the Seattle city limits in the West Hill PAA at the south end of the Lake. Observations regarding land-use and lake shore modifications, such as docks and bulkheads, were recorded to provide current information about the lake shoreline. The analysis of lake shoreline modifications included interpretation of 2005 and 2007 King County aerial photography (King County 2005; King County 2007); and analysis of 2006 and 2007 Ecology oblique photography (Ecology 2006; Ecology 2007) (Maps 11a to 11e).[14]

---

[13] WAC 173-26-201 (2)(c)

[14] Although the oblique photography is recent, this analysis may not contain all of the most recent dock or shoreline armoring developments.

In addition, the 2007 King County Shoreline Inventory and Characterization report was used to characterize the Lake Desire shoreline and Reach K of the Lake Washington shoreline (King County 2007). The report characterized ecosystem processes, land-use, archaeological and historic properties, and identified potential restoration opportunities.

This report includes up-to-date information on land-use, zoning, public access, impervious surface, water quality, priority habitats and species, and lake shore modifications.

3. ECOSYSTEM-WIDE CHARACTERIZATION

Ecological structure and function in shorelines are driven by physical and biological processes occurring at varying spatial scales across the entire ecosystem. These processes operate within a physical structure defined by geology and climate. Processes affect shoreline structure and function through the input, transport, storage and/or loss of materials, including water, sediment, chemicals, and organic matter.

Although many of the processes that affect ecological function in the City's shorelines occur outside the city and are outside the City's control, an understanding of their impact is important when considering the potential for management actions that may be undertaken by the City. For this reason, SMA guidelines require local jurisdictions to look beyond shorelines and 'assess the ecosystem-wide processes to determine their relationship to ecological functions present within the jurisdiction'.[15]

The following ecosystem characterization defines the area contributing to shoreline functions in the City, identifies the hydrogeologic controls and physical processes that occur, and characterizes changes to processes resulting from land-use. In addition, important areas where processes can be managed with the highest return on investment are identified, with emphasis given to areas within the City.

3.1 STUDY AREA

Jurisdictional shorelines in the City of Renton lie within the Lake Washington/Cedar River (Water Resource Inventory Area [WRIA] 8) and the Green/Duwamish River (WRIA 9) watersheds, and these two watersheds comprise the study area for the ecosystem characterization (Figure 3-1). Information presented below is either taken directly or modified from literature produced as part of WRIA planning and is supplemented by ecosystem characterizations recently conducted as part of SMP updates prepared by King County and incorporated cities, including Kirkland, Tukwila, and Sammamish.

WRIA 8 encompasses 692 square miles (Kerwin 2001) and two major subbasins, the Sammamish River and the Cedar River, both of which flow into Lake Washington. Lake Sammamish, Lake Washington, Lake Union, and numerous tributaries to each. WRIA 8 is located predominantly within King County, with the northwest portion extending into Snohomish County. WRIA 8 boundaries follow topographic divides between WRIA 7 (Snohomish River) to the north and east, and WRIA 9 (Green/Duwamish Rivers) and Puget Sound to the south and west (Kerwin 2001). The majority (approximately 86 percent) of WRIA 8 is in the Puget Lowlands physiographic region. The upper Sammamish drainage lies in the Cascade foothills, while the upper Cedar River drainage extends through the foothills into the Cascade Mountains. WRIA 8 has a population of about 1.5 million people, the most of any WRIA in the state. The City's population of 80,708 is about one half of one percent of the total population of WRIA 8.

WRIA 9 contains the Green River and its tributaries, including the Duwamish waterway/estuary, and nearby tributaries draining directly to Puget Sound. WRIA 9 is bound topographically by WRIA 8 (Lake Washington/Cedar River) to the north and WRIA 10 (Puyallup River) to the south. The Green River watershed is 462 square miles, and the river itself stretches 93 miles from its source in the Cascade Mountains through the Cascade

[15] WAC 173-26-201(3)(d)(i)

foothills and Puget Lowlands before emptying into Puget Sound at Elliott Bay. The population of WRIA 9 is approximately 565,000.

The City accounts for less than three percent of the geographical area and its population (80,708) is less than a half of one percent of the population of about two million within WRIAs 8 and 9. The City is also located near the lower end of both WRIAs. Hence, management actions taken within the City limits have a limited effect on overall watershed conditions. However, actions taken to manage reach-scale processes, such as riparian and floodplain functions, could have a larger effect on specific ecological processes and functions, particularly rearing functions of anadromous fish.

The City also lies in the lower portion of May Creek and Springbrook Creek but accounts for a much larger proportion of the total watershed area. As such, management actions for these shorelines conducted within the City may have a more substantial effect on overall watershed conditions and shoreline ecological functions. Given this context, the ecosystem characterization is conducted using a broad resolution at the WRIA-scale, with emphasis placed on processes occurring within the City. The characterization highlights the potential for process-based restoration of ecological structure and function within the City limits.

3.1.1 Hydrogeologic Setting

The existing Lake Washington and Green River watersheds exhibit geology, climate, and topography typical of most Puget Lowland drainages (Maps 3a, 3b, and 4a). The major rivers in WRIAs 8 and 9 were shaped by the underlying geologic features found throughout the region and include uplift and mountain building, volcanic activity, glaciation, marine deposition, and post-glacial alluvial deposition. Climate is driven by maritime patterns that foment mild, wet fall to spring months and cool dry summer months.

In lowland areas in and around Renton, glacially deposited sediments underlie alluvial floodplains. Drift in the Renton area consists principally of till (Qvt), advance outwash sand and gravel (e.g., sediment deposited by water flowing off the advancing glacier; Qva), and recessional outwash sands and gravels (e.g., sediment deposited by water flowing off the receding glacier). In some areas the till is dense enough to act as an aquitard, limiting vertical groundwater movement. Overlying alluvial sediments contain 15 to 20 feet of recent deposits underlain by older, coarser alluvium that can be up to 90 feet thick. Deposits are often capped by fill as a result of urban developments (Fabritz et al., 1998) such as Renton Municipal Airport. Subsurface geology in the vicinity of the City is a combination of bedrock, glacial, and interglacial sediments.

Mean annual precipitation in the City is 42 inches, most of which accumulates between October and May. Precipitation in the Puget Lowlands typically occurs as low-intensity, long-duration storms. Snowfall is uncommon and short-lived, but snowpack can range from around 50 inches at elevations above 2,000 feet to several hundred inches at elevations greater than 5,000 feet in the Cascade Mountains, where total water equivalent precipitation averages between 60 and 100 inches per year (National Climate Data Center [NCDC] 2008).

Upstream of the lowlands, the major rivers and their tributaries flow through upland plateaus consisting of glacial drift (e.g., sediment deposited directly or indirectly by a glacier or associated meltwaters). The headwaters of the Sammamish basin extend only to the Cascade foothills, and groundwater plays an important role in sustaining annual stream flows. The same is true for lowland streams found in the City such as Springbrook and May Creeks.

In the headwaters of the Cedar and Green Rivers, snowpack melting from high in the Cascade Mountains drives discharge of both water and sediment, a result of the cold temperatures, steep slopes and shallow soils commonly found where volcanic bedrock has uplifted.

The following sections describe the processes and alterations for each basin with jurisdictional shorelines within the City boundaries.

3.1.2 Land Conversion, Development, and Management

WRIAs 8 and 9 have similar development histories and existing land-use patterns (Kerwin 2001). Settlement of Puget Sound by non-indigenous peoples began in the 1850s. Subsequent to the Treaty of Elliott Point in 1855, tribes were relegated to reservations, and rapid development and resource consumption ensued. In addition to the creation of settlements and small towns, early land-use activities included dredging and channelizing the Green and Cedar Rivers to improve navigation, constructing rail corridors, and land clearing associated with agriculture and forestry. Flood control soon followed to protect forest and agricultural practices, including the reconfiguration of the watersheds' hydrologic architecture discussed above (dams, drinking water diversion, Lake Washington inflow and outflow reconfiguration).

As population in the area grew, land-uses in lowland areas transitioned from forestry and agriculture to urban development, including medium- and high-density residential, commercial, and industrial development. Industrial land-use was established at various locations, including along the Duwamish Waterway, which continues to be an important waterborne transportation corridor. Some of the industrial development on Lake Washington was water-dependent; for example, sawmills depended on currents to transport rafted logs.

For the most part, present-day industrial development on Lake Washington is not water-dependent. The primary uses of City shorelines are residential, public park, and open space.

Originally, WRIAs 8 and 9 were a single, large watershed (Figure 3-1). A number of physical alterations to the watershed, completed in the early 20th century, were intended to improve navigation, control flooding, increase land availability, and develop drinking water resources for a burgeoning population. These changes irrevocably changed the original watershed hydrography.

Some of these alterations include:

- 1911 White River permanently diverted from Green River to Puyallup River
- 1912 Masonry Dam closure on the Cedar River; drinking water diverted for City of Seattle
- 1913 Drinking water diversion on the Green River constructed by City of Tacoma
- 1916 Lake Washington outflow diverted to Hiram-Chittenden Locks and lake levels lowered 9 feet
- 1916 Cedar River discharge diverted from Black River to Lake Washington; due to lowering of Lake Washington, Black River dried up except for the short section sustained by discharge from Springbrook Creek
- 1917 Duwamish Waterway constructed
- 1940 Most of Green/Duwamish estuarine wetlands converted to developed land
- 1962 Howard Hanson Dam built for Green River flood control

These alterations resulted in the creation of two distinct watersheds and reduced the mean annual discharge of both the Green and Cedar Rivers (Figure 3-1). Originally, the Cedar River and Lake Washington flowed via the Black River into the Green River and the

Duwamish estuary. The total area draining to the Duwamish estuary included 692 square miles in the existing Lake Washington watershed—of which 607 square miles are drained by the Cedar River. In addition, the White River historically was a major tributary of the Green River, adding an additional 494 square miles to the total drainage area. Today, the White River is part of the Puyallup River watershed; the Cedar River flows into Lake Washington and is now in a separate watershed from the Green River.

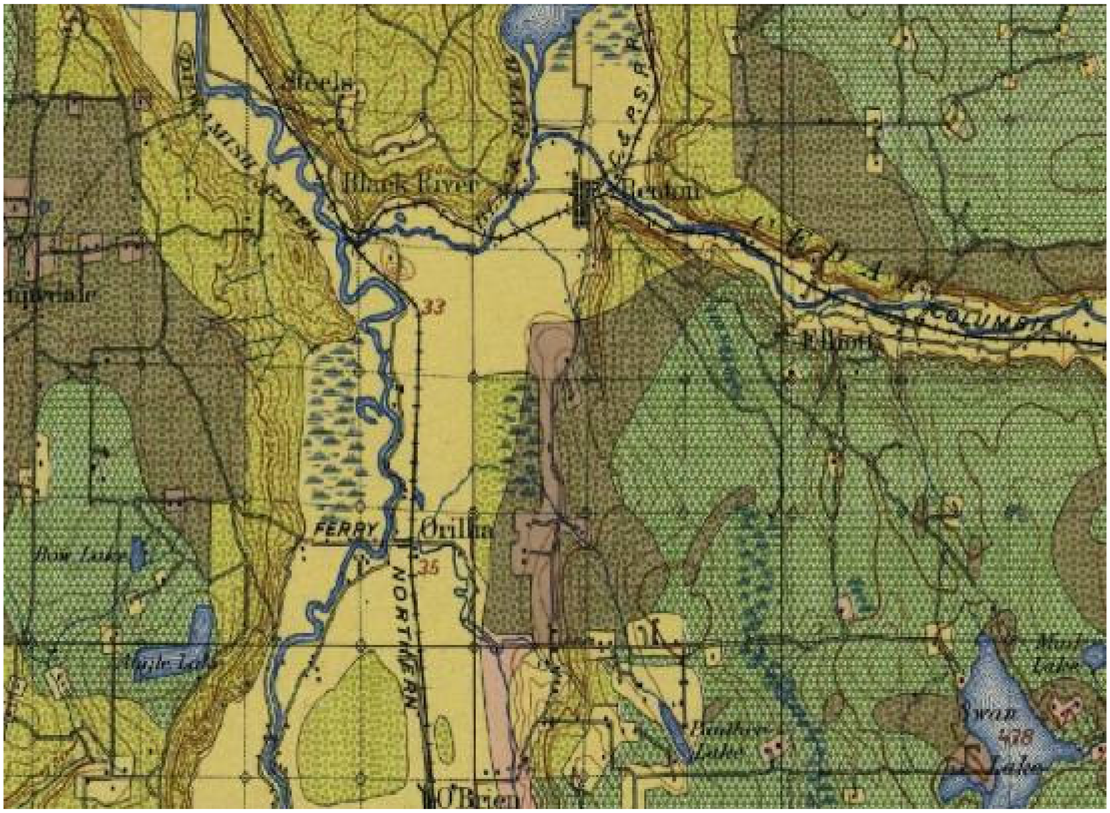

Figure 3-1. Cedar River Prior to Diversion

Source: USGS 1895

3.1.2.1 Existing Land Use

Both upper watersheds support drinking water supplies and are therefore protected to varying extents. In WRIA 8, Sammamish River headwaters do not extend into the Cascade Mountains; headwaters lie in upland plateaus and land-use is as discussed previously in Section 3.1.2. In accordance with the Cedar River Habitat Conservation Plan, forestry has been discontinued in favor of conservation. In the Green River headwaters, upstream of the Tacoma water diversion, forest practices continue over the entirety of the land, but public access is limited. Below the tree line, land cover is forest of varying seral stages and a small amount (less than 10 percent) of land-use is residential (Kerwin and Nelson 2001).

Between the Cascade Mountains and urbanized areas, forestry and agricultural land account for approximately 50 percent of land-use. The remaining land-use is primarily rural residential development.

In urban areas, residential land-use makes up 40-60 percent of development, depending on the area. An additional 30 percent of land is typically apportioned for commercial and industrial use. One exception is the area surrounding the Duwamish Waterway, for which industrial uses make up 43 percent of land-use. The City of Renton is located in the highly urbanized lower watershed. Development in the City mirrors general land-use patterns in surrounding urbanized areas.

3.2 ECOSYSTEM-WIDE PROCESSES

Watershed physical processes deliver, transport, store, and remove materials from the ecosystem, thereby affecting the structure and biological functions of river and lake shorelines. The movement of water, sediment, chemicals, and organic material occur throughout the landscape, but these processes occur at varying intensities, depending on local geologic and climate conditions. The following section describes ecosystem processes, and identifies areas most important for supporting those processes. This section summarizes conditions broadly across the entire study area.

3.2.1 Water

The cycling of water through the ecosystem is dependent on geologic and climate controls such as slope, elevation, precipitation type and amount, soil permeability, storage potential on the surface (landform), and underground (soil porosity) (Figure 1-1).

Water is input to the watershed system via either rain or snow. In upper elevations, snowfall typically remains until late spring and early summer, when it melts and swells rivers and streams. During winter months, between the elevations of 1,500 and 4,500, storm events can occur, during which rain falls on existing snowpack, melting the snow and causing flood events. At elevations below 1,500 feet, precipitation occurs mostly in the form of low-intensity rainfall that infiltrates the soil to recharge groundwater or is delivered to surface water bodies via shallow subsurface flow.[16]

During rain-on-snow events or other episodes that cause flooding, storm flow can be attenuated through temporary storage in floodplains, wetlands, lakes, and in-channel features that add roughness and decrease flow velocities. Typically, storage areas occur near low-gradient streams and in lowland areas where physical relief is very low, coarse glacial outwash stores high volumes of water, and subsurface flow velocities are rapid. Water can be transported to storage areas via hyporheic (i.e., flow through streambeds and soils near stream channels) and overbank flow.

Alternatively, precipitation can infiltrate the soil to recharge groundwater. The geologic characteristics of upland plateaus, where land transitions from lowlands to the Cascade foothills, make them important areas for groundwater recharge. Upland plateaus contain coarse outwash, deposited by receding glaciers. This coarse outwash overlays fine-grained till and creates a soil with a high infiltration rate. Furthermore, upland plateaus receive more precipitation than lowland area. The result is that upland plateaus have a very high potential to recharge groundwater. However, till underlying coarse deposits can also act as an aquitard, preventing infiltrated water from percolating to recharge deep, underlying aquifers. Instead, water is confined and creates wetlands or moves laterally above confining till layers to discharge to streams. Deeper aquifers are also confined by layers of till interspersed with coarse deposits. Groundwater moves laterally and eventually discharges in lowland areas to support baseflow in lakes and rivers.

---

[16] Rainfall rates can also exceed soil infiltration capacity, causing overland flow, which combined with shallow subsurface flow and groundwater discharges augments streamflows and sometimes causes flooding.

3.2.2 Sediment

The cycling of sediment through an ecosystem is dependent on geologic features such as slope, land cover, soil cohesion, and storage potential determined by landform, and climate features such as precipitation duration and intensity. Also important are interactions (including impairments) with the hydrologic process, which is a vehicle for sediment delivery and transport. Therefore, many of the alterations to the hydrologic process also directly and indirectly affect the sediment process.

The primary mechanisms for sediment delivery to aquatic systems are mass wasting and soil erosion. Mass wasting in the form of shallow landslides typically occurs on steep slopes of a certain curvature. The vast majority of landslide hazard areas occur in the Cascade Mountains and, to a lesser extent, the foothills. These areas are underlain by volcanic deposits, which contribute valuable gravel and cobble to streams. The Green River gorge has important localized sources of coarse sediment input where steep walls deliver sediment to the river (Kerwin 2000). Landslides occur along the steep slopes marking upland-lowland transition and in the ravines of tributary streams as they cut through this transition. Bedrock in these areas is sedimentary and delivers a higher proportion of silt and sand.

Soil erosion is a function of soil erosivity, slope, and cover. Steep slopes with erosive soils also contribute fine sediment to water bodies, not high quality gravel and cobble substrate. Erosive soils are most commonly associated with alluvium and outwash. Therefore, the Cascade foothills and steep plateau-upland transitions have a high potential for surface erosion in addition to landsliding.

Important areas for sediment storage are the same as those described for water. Depressional areas such as lakes, wetlands, and floodplains allow for the precipitation of suspended sediment in slack water. Additionally, larger streams and rivers with low gradients cycle sediment through periods of transport and storage as they migrate laterally across the floodplain. Therefore, alluvial deposits in floodplains are an important source of high quality substrate.

Processes for sediment delivery to lakes include the delivery of sediment via tributaries and bank erosion. Inputs remain localized, and mechanisms for transport are limited. These areas provide extremely important, high quality habitat in lake ecosystems.

3.2.3 Water Chemistry

The delivery of elements and compounds to water bodies is highly dependent on water and sediment processes that provide a vehicle for dissolved and adsorbed materials transportation. Vegetation and the atmosphere also play a role in the delivery of certain compounds/elements. These mechanisms for delivery do not result in background levels that degrade ecological structure and function in the study area, although aluminum may naturally occur at relatively elevated levels (Kerwin and Nelson 2001). Furthermore, they do not typically occur in important, localized areas on the landscape (Stanley et al. 2005). While important areas for input of these materials are not identified, the discussion of alterations to delivery of contaminants in a subsequent section (Section 4) will include a description of important areas.

Storage of materials that affect water quality is similar to those for sediment, where adsorbed compounds, including phosphorus, nitrogen, and toxins can be deposited and potentially removed via biotic uptake. Wetlands with mineral soils are important areas where dissolved phosphorus can undergo adsorption and storage. Toxin storage, however, is better facilitated by wetlands with clay or organic soils where adsorption and biotic uptake is better catalyzed (Stanley et al. 2005). Nitrogen cycling and storage is fomented by small streams, where alders have a great capacity for nitrogen uptake in hyporheic zones. Nitrogen cycling is also augmented by wetlands with non-organic soils (denitrification) and pH-neutral or alkaline soils (nitrification; Stanley et al. 2005).

Areas in upland plateaus have a high frequency of peaty and clay wetlands underlying surficial geology (Map 4b) and are important areas for toxin storage, denitrification, and adsorption and deposition of dissolved contaminants. Lowland wetlands are more likely to be either fine grained, where floodplain deposition has occurred, or mineral, where coarse-grained alluvium is present. These depositional areas also support deposition of adsorbed contaminants.

Like wetlands, lakes are depositional areas that have a high potential for storage of adsorbed materials. Streams, deltas, shallow water areas, and lacustrine wetlands are all depositional areas near lakeshores where contaminants can be stored. If nutrient/contaminant loading increases, sediment quality can be impaired. Destruction or disturbance of these sinks can render a lake more susceptible to eutrophication (a state of high algal productivity that decreases dissolved oxygen [DO] levels) or ecological responses to water quality impairment.

3.2.4 Organic Matter

Organic materials include living organisms and the carbon-based material they leave behind after dying, including coarse woody debris, finer woody debris, and detritus. These elements are important for the cycles of energy and nutrients in aquatic ecosystems, including storage, transport, and chemical transformation (Naiman 2001). Downed trees play a significant role in the aquatic ecosystems of the Pacific Northwest. Large woody debris (LWD) significantly influences the geomorphic form and ecological functioning of riverine ecosystems (Maser et al. 1988; Nakamura and Swanson 1993; Collins and Montgomery 2002; Abbe and Montgomery 1996; Collins et al. 2002; Montgomery et al. 2003a; Montgomery et al. 2003b). In a natural system, LWD provides organic material to aquatic ecosystems and is considered a principal factor in forming stream structure and associated habitat characteristics (e.g., pools and riffles). Riparian vegetation is the key source of LWD. LWD is primarily delivered to rivers, streams, or wetlands by mass wasting (landslide events that carry trees and vegetation along with sediment), windthrow (trees, branches, or vegetation blown into a stream or river), and bank erosion (Stanley et al. 2005). Thus, riparian areas, steep forested slopes adjacent to streams, and channel migration zones are important areas for LWD recruitment.

3.2.5 Other Processes

Other secondary processes have less widespread but important influences on overall ecological function in shorelines, including heat/light inputs, biotic interactions, and habitat connectivity. Climate change may already be acting to increase water temperatures as the region experiences a warming trend (Kerwin 2000), and riparian vegetation, channel morphology, and water input source also contribute to overall temperature regimes in water bodies. The introduction of invasive plants and animals can have a significant influence on community productivity through competition, food web dynamics, and predator-prey interactions, among others. Habitat connectivity, which may be limited by natural barriers such as waterfalls, can also limit community or population productivity by limiting availability to valuable habitat.

Shoreline vegetation contributes to a wide range of ecological functions within shoreline areas. Vegetation contributes to habitat functions for a range of fish and wildlife species. Healthy environments for aquatic species are linked with the surrounding terrestrial ecosystem including vegetation cover. Commonly recognized functions of the shoreline vegetation include:

- Providing shade necessary to maintain the cool temperatures required by salmonids, spawning forage fish, and other aquatic biota.
- Providing organic inputs critical for aquatic life.
- Providing food in the form of various insects and other benthic macroinvertebrates.
- Stabilizing banks, minimizing erosion, and reducing the occurrence of landslides. The roots of trees and other riparian vegetation provide the bulk of this function.
- Reducing fine sediment input into the aquatic environment through storm water retention and vegetative filtering.
- Filtering and vegetative uptake of nutrients and pollutants from groundwater and surface runoff.
- Providing a source of LWD into the aquatic system. LWD is the primary structural element that functions in streams to provide hydraulic roughness element to moderate flows. LWD also serves a pool-forming function in streams, providing critical salmonid rearing and refuge habitat. Abundant LWD increases aquatic diversity and stabilization.
- Regulating of microclimate in the stream-riparian corridors.
- Providing critical wildlife habitat, including migration corridors and feeding, watering, rearing, and refugia areas
- LWD provides cover from birds, fish, and other juvenile salmonid predators.

Large woody debris (LWD) is generally recognized as an important element of the natural shoreline of Lake Washington. Under natural conditions it provides shoreline complexity that may have a role in providing refuge area for juvenile salmon and other species. It is also an important organic input and is important to the overall function of the food chain. The role of woody debris in the predator-prey dynamics in the shallow littoral environment, especially with non-native predator species, has not been clearly established.

Sustaining different individual functions requires different widths, densities, and compositions of vegetation. The importance of the different functions varies with the character of shoreline setting. Figure 3-2 provides an illustration of the functions of riparian vegetation in an urban setting.

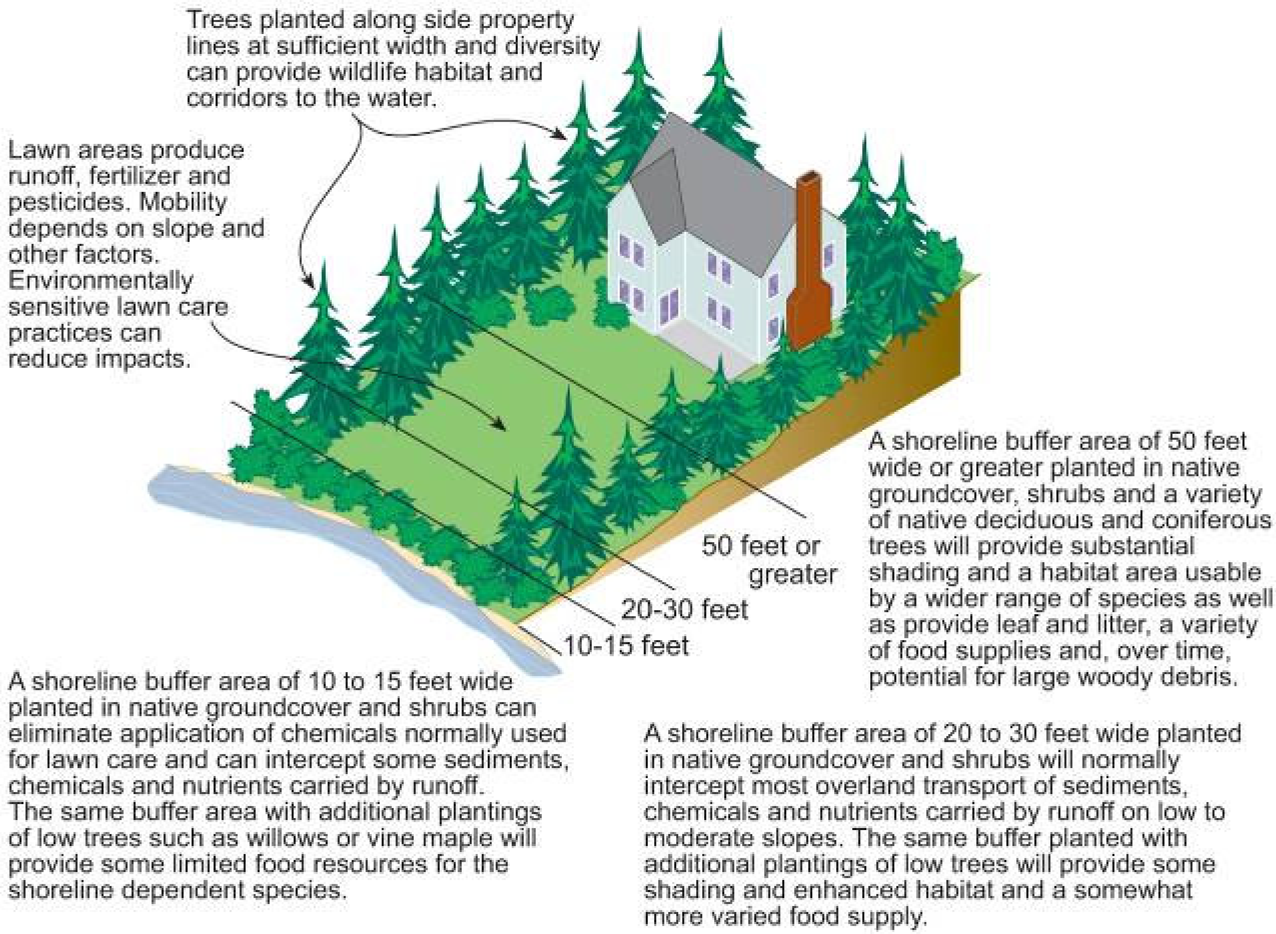

Figure 3-2. Riparian Vegetation Function in an Urban Setting

3.3 PROCESS IMPAIRMENTS

Both regional water resource management and land-use have altered watershed processes in WRIAs 8 and 9. The two watersheds are somewhat unique in that they provide drinking water for the two largest urban areas in the Puget Sound, Seattle and Tacoma. Water resource management creates important social benefits but also disrupts natural watershed processes that historically occurred in the basin. In addition, historic, regional planning actions to improve transportation and supply hydroelectric power have directly altered processes and degraded shoreline ecological function. The potential for the City of Renton to restore processes and ecological function via this management framework is limited, as management occurs at a regional level. Therefore, the effect of water resource management on watershed processes is discussed briefly, but the analysis is not extended to the identification of management opportunities.

The City has the potential to improve ecosystem function through land-use management, including conservation and restoration actions both inside and outside of City limits. Forest practices, agriculture, and rural and urban development all impact processes by changing land cover and limiting process connectivity. Watershed analyses presented below discuss the effect of these activities on watershed processes and identify priority management areas for protecting and restoring processes. A watershed analysis is conducted for each water body-containing jurisdictional shoreline within the City.

3.3.1 Regional Water Resource Management and Impacts

Management actions taken in the early 1900s to improve transportation, improve development potential, and develop water resources profoundly impacted watershed processes. As discussed previously (Section 3.1.2), these actions included redesign of watershed architecture, including management of Lake Washington water levels, production of hydroelectric dams, and consumption of surface and groundwater.

3.3.1.1 Watershed Hydrography

The redesign of watershed architecture included diverting the White River to the Puyallup River watershed, diverting the Cedar River from the Green River to Lake Washington, and diverting Lake Washington/Sammamish River from the Green River to Salmon Bay. These alterations reduced the watershed area of the Green River by 60 percent and mean annual discharge by 70 percent (Kerwin and Nelson 2000).

Glacial melt supports summer flows on the White River. Its diversion from the Green River caused a disproportionate reduction in summer low flows. These low flow conditions reduce the availability of rearing habitat, and associated increases in temperature reduce juvenile growth rates and may present migration barriers to escaped adult habitat. The White River historically contributed 70 percent of the gravel to the Green River downstream of river mile 32 (Mullineaux 1970), all of which was lost when it was redirected to the Puyallup River. This change has degraded substrate quality and the availability of gravel suitable for salmonid spawning. The White River also contributed a major portion of groundwater to the shallow aquifer used by the City of Auburn for drinking water (Pacific Groundwater Group 1999 as cited in Kerwin and Nelson 2001). Loss of this recharge source causes a concern for the sustainability of the water resource. However, the effect of the White River diversion on groundwater flow and recharge is not currently well-understood because of lack of historic data.

The redirection of the Cedar River also reduced streamflow in the Green River. The Cedar River, however, entered the Green River very low in the watershed, so the alteration, in conjunction with drinking water diversions and the White River diversion, affected primarily the Duwamish estuary. Access to the Cedar River by native salmonid populations was also cut off. Salmon stocks naturally adapted to the new outlet through Lake Union and the ship canal and most species are still found in the system. However, Green River pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon stocks thought to exist historically in the Cedar River are no longer present.

The operations at the Howard Hanson Dam, the City of Tacoma's water diversion, and other water municipalities have affected water flows in the Green River. These facilities now dictate summer minimum flows and have led to drastically reduced spring flows.

3.3.1.2 Lake Washington Hydrology

The lowering of Lake Washington's elevation and the engineering of the inflow/outflow regime is the most significant alteration to ecosystem processes, including direct hydrologic effects and interactive effects on other processes. The lake-level lowering reduced total surface area by seven percent and shoreline length by 12 percent (Kerwin 2001). In addition, the lake edge has been converted from shallow water and wetland habitat to deep water habitat (Kerwin 2001). In total, more than 1,300 acres of shallow water habitat were lost (Kerwin 2001).

The U.S. Army Corps of Engineers (USACE) regulates water level fluctuations in the Lake. The managed range of fluctuation is one-third of the historic fluctuation, and the timing of fluctuation has been reversed. Whereas Lake levels were historically lowest during the summer, the opposite is true today. The altered hydrology creates some benefits for lakeshore property owners and recreational users but has impacted Lake ecology. Substantial areas of shallow water habitat that provide important habitat for juvenile salmonids and associated ecological communities were lost. Changes in the natural hydrologic regime also affect native fish, wildlife, and plant species adapted to natural fluctuations of the water level. Fluctuations are known to alter aquatic macrophyte communities (Cooke et al. 1993). No historic data are available, but riparian vegetation has responded to the altered hydrologic regime; aquatic plants adapted to shallow water habitats and terrestrial vegetation adapted to drier summer conditions have been lost.

3.3.1.3 Dams and Drinking Water Diversion

Dams and drinking water diversions on both the Cedar River and Green River have disrupted material (i.e., water, sediment, wood, chemicals, heat) transport processes and split each river into two distinct areas. Upstream watershed processes are generally intact, but the influence of those intact processes on downstream ecological structure and function has been muted. Functions that are affected include:

- Fish passage/migration
- Timing and amount of water delivery and storage
- Sediment and organic matter storage and transport

At the time of construction, none of the four dam/diversion structures were designed for fish passage. The Masonry Dam on the Cedar River lies upstream of a natural fish passage barrier, but the remaining three structures limit the ability of fish to access historically available habitat. The Landsburg Diversion cut off 12 miles of the Cedar River previously accessible to salmonids below Cedar Falls, while the upper 28.5 miles of the Green River and its tributaries were also rendered inaccessible (Kerwin 2000). Fish passage was included for the Landsburg Diversion as a provision of the 2001 Cedar River Habitat Conservation Plan (HCP), but the Green River structure currently remains impassable.

The Instream Flow Incremental Methodology was used to develop a flow regime under the existing Cedar River HCP (2001) intended to sustain both salmonid populations and the drinking water supply. The City of Seattle currently has rights to 105 million gallons per day (mgd) of water and flexible rights up to an additional 95 mgd, depending on timing and necessity, or approximately 25-30 percent of total annual discharge (Kerwin 2000). On the Green River, the City of Tacoma was granted the right to divert up to 113 cfs from the Green River, or 12 percent of the annual flow at the point of the diversion (Kerwin and Nelson 2001).

In addition to the amount of discharge, the timing and intensity of discharge have been altered by flow control structures. On the Green River, peak flows have been reduced to prevent downstream flooding and the historic bankfull discharge (analogous to the 2-year recurrence interval flood) never occurs. The duration of moderate flows has increased in the winter, and water that would normally produce spring freshets from snowmelt are held back to augment summer low flows. This effort to create low flow augmentation does not fully compensate for the water diverted by Tacoma during the summer, and summer low flow discharge remains lower than historic averages (Kerwin and Nelson 2001).

Altered flow conditions have a number of structural and functional consequences. Reduction in flood events limits the capacity of rivers to renew themselves, including forming habitat features and transporting sediment downstream and storing it in the floodplain. Biotic communities adapted to natural flow regimes are affected as well. Juvenile salmonids use spring freshets to indicate migration and smoltification. Plants, such as cottonwoods, are also dependent on flooding for germination. Reduced summer low flows may alter the migration timing of escaped adult salmon returning to spawn and affect water temperature and DO levels.

A trap and haul system has been constructed to remove adult salmon around the Tacoma Public Utilities Headworks Diversion Dam and Howard Hanson dams. USACE is constructing a juvenile fish collection system so that juveniles migrating downstream through Howard Hanson dam may be collected and trucked downstream. The TPU diversion dam is outfitted with a fish ladder and fish screen system.

Dams and diversions also affect sediment storage and transport. The high quality gravels derived from volcanic rock are unable to pass the dams, although the Landsburg Diversion on the Cedar River does pass some gravel during peak flows. Particularly on the Green River, this fact, coupled with the lack of peak flows that can initiate substrate transport, prevents gravel from being replenished. Storage of the available sediment behind the dam has contributed to channel armoring and incision in downstream areas. Finally, flood storage behind dams that reduces peak flows also extends the duration of high flows. This affects sediment transport and stream bank erosion, which, consequently, affect ecosystem processes (Kerwin and Nelson 2000).

The dams also prevent the normal process of wood transport to downstream areas. The Howard Hanson dam is relocating a portion of the wood and sediment that is entrained above it to downstream areas as mitigation for its operations. While this is an improvement over past practices, the entrainment of wood and sediment at the dam has implications for downstream areas in that the entire source of wood and sediment is not available due to these structures. The result is that the remaining sources of sediment and wood recruitment become more important to creating and sustaining fish habitat and the removal of large trees a potential significant impact. The combination of these circumstances with existing areas that do not have trees or the potential to grow trees to maturity because of land use presents a challenge to restoration of structural conditions analogous to native fish habitat.

3.3.2 Watershed Analyses

Land-use effects on watershed processes are presented below for each basin with jurisdictional shoreline within the City. The analysis includes identifying priority areas for process-based protection and restoration. In general, emphasis for protection and restoration depends on land-use and the degree to which the area supports ecosystem-wide processes (Figure 3-3). The two criteria for rating functions result in three general categories:

- Areas with the highest priority for protection and preservation are the areas with a moderate to high importance for processes and moderate to low levels of alteration which have the highest priority to allow the processes to continue with minimal change in existing conditions.
- Areas with for restoration may have a range of importance for processes and a range of alteration. The graphic indicates that priority is generally based on the importance of the process, rather than the extent of alteration. Some areas of high alteration may have high potential for restoration if the affected processes are important.
- Areas with low importance for processes and high levels of alteration generally are those areas with the greatest suitability for development for human use, which generally entails loss of ecological processes.

Basin analyses also provides a perspective of the City's location in the watershed and the relative capacity for protecting and restoring processes within the City limits and UGA.

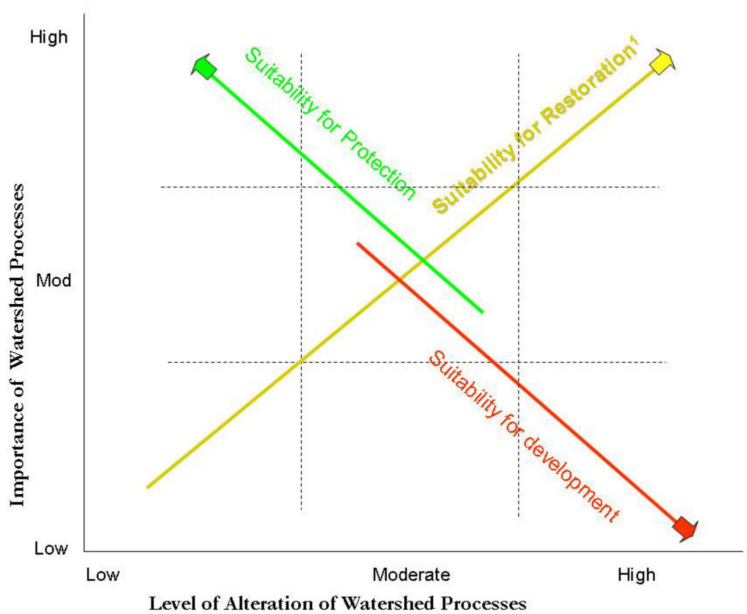

Figure 3-3. Rating of Priority Areas for Process-based Protection and Restoration.

3.3.2.1 Lake Washington

The Lake Washington basin includes most of the 692 square miles contained in WRIA 8 and is populated by approximately 1.5 million people (Kerwin 2001). Two major subbasins comprise the watershed, Lake Sammamish and Cedar River, both which flow into Lake Washington. Lake Sammamish, Lake Washington, Lake Union, and numerous tributaries to each are also part of WRIA 8. The City of Renton lies at the south end of Lake Washington and contains the mouth and about 6 miles of the lower of the Cedar River. Approximately 21 mi^2, or 3 percent, of the total watershed area lies within City limits. The City's population of 80,708 is less than one-half of one percent of the total population of the watershed.

Altered sediment inputs are not identified in existing literature as limiting to the ecology of the Lake, but development and associated bank hydromodification have reduced the natural coarse sediment inputs in stream deltas and along the lakeshore, respectively. Dredging has altered delta physiography where it occurs, such as the mouth of the Cedar River and May Creek. These deltas potentially support a high degree of ecological function (Gracie 2004, Riley 1998), including shallow water habitat, spawning grounds for lake-type sockeye, and attachment substrate for macroinvertebrates and benthic organisms. Dredging of the mouth of the Cedar River has been determined to have little or no positive impact on flood control and is not expected to be proposed in the future (Straka 2009c). Dredging of the delta of May Creek formerly occurred at the Barbee Mill sawmill to enable log storage. With the closure of the mill, dredging has ended, and delta formation and structure are expected to eventually return to a more natural dynamic, although this may require several decades (Renton 2003).

Lake sediments are a sink for pathogens and toxins and the resulting sediment quality can influence lake ecology. Due to limited transport and mixing of sediments, poor sediment quality is usually localized in stream deltas and old industrial sites (Kerwin 2001). Moshenberg (2004) found that Lake Washington sites contained elevated levels of polychlorinated biphenyls (PCBs), but that tributyl tin, metals, and polyaromatic hydrocarbon levels were not above normal. Levels of dichloro-diphenyl-trichloroethane (DDT) are decreasing from historic levels when DDT was unregulated, and recent inputs are not apparent (Moshenberg 2004).

Sediment input from upstream sources is also a vehicle for the introduction of phosphorus into the Lake. However, historic eutrophication in the Lake resulted from the direct sewage discharge (Kerwin 2001). This practice was discontinued in the 1960s, and the Lake reverted to its natural mesotrophic condition. Tributaries are now the primary sources of phosphorous inputs to the Lake. While these inputs have not currently altered the natural trophic state of the Lake, the potential for such an effect remains if tributary water quality deteriorates due to future build-out and associated increases in sediment and phosphorous loads (Kerwin 2001).

Tributary discharge and other runoff (e.g., overland flow) are also sources of nitrogen, pathogens, and toxins that affect water quality in the Lake. Currently, 15 sites along the Lake are listed as having impaired water quality (Ecology 2008; Table 3-1). Dioxin, benzene, and chlordane are all pesticide derivatives with other various industrial uses. Benzene is a bi-product of DDT degradation, which was banned as a pesticide agent but is environmentally persistent. These toxins have low solubility and are typically found in sediments, where they bioaccumulate through the food web. Most sites are associated with industrial sites or tributary mouths. See Map 7 for areas of impaired water quality along the City's shoreline.

Table 3-1. 303(d) Water and Sediment Quality Impairments for Lake Washington

		Number of Sites			
		2004		2008	
Compound	**Medium**	**Impaired**	**Area of Concern**	**Impaired**	**Area of Concern**
Phosphorus	Water			2	
Ammonia	Water	2	8		4
Fecal Coliform	Water	15	4	15	4
Dioxin	Tissue			2	3
Benzene (DDT derivative)	Tissue			3	2
Chlordane	Tissue			1	
Lead	Tissue		1		1`
Mercury	Tissue		2		1
PCBs	Tissue	1	8	4	8
Sediment Bioassay	Sediment	2		NA	NA

Source: Ecology (2008)

In addition to watershed-scale processes, the Lake's ecology has been affected by shoreline-scale processes and human-induced changes in biotic interactions. Bank armoring (i.e., bulkheads) has contributed to the reduction in availability of shallow water habitat. In conjunction with the alteration to riparian areas, bank armoring has led to a substantial reduction in natural shoreline vegetation and allochthonous organic inputs. Inputs include LWD that provide natural above- and in-water cover preferred by rearing and migrating juvenile salmonids, respectively. In addition, those sockeye salmon (*O. nerka*) with a lake-type life history are reliant on lakeshore with gravel and groundwater upwelling suitable for spawning. However, functionality in these key areas is severely limited by bulkheads or other shoreline modifications. Currently, existing cover is predominantly in the form of docks, piers, floats, and other man-made structures. Such structures provide excellent habitat for non-native warm water species such as yellow perch (*Perca flavenscens*), brown bullhead (*Ameiurus nebulosus*), smallmouth bass (*Micropterus dobmieu*), and largemouth bass (*Micropterus salmoides*). These species use these structures as cover to prey on juvenile salmonids.

The introduction of non-native species into the Lake's ecosystem has had a profound effect on biotic interactions, including macrophytes, macroinvertebrates, and fishes. Non-native, invasive macrophytes such as Eurasian aquatic milfoil (*Myriophyllum spicatum*) and fragrant white water lily (*Nymphaea odorata*) existing in large quantities in Lake Washington have a demonstrated negative effect on native fish communities (Frodge et al. 1995). Such flora reduced DO levels locally in areas of poor mixing. Invasive species use areas infested with invasive macrophytes (such as areas shaded by overwater structures) to prey on juvenile salmon, particularly Chinook (*O. tshawytscha*), which tend to remain in the Lake through the height of annual milfoil production.

3.3.2.2 Cedar River

The Cedar River drains 191 mi^2 of area, 125 mi^2 of which lies upstream of the City of Seattle drinking water diversion. Almost 100 percent of the land upstream of the Landsburg Water Diversion is owned by the City of Seattle and is maintained as natural environment to protect the city's drinking water resource. The upper watershed is mostly second growth forest, but 16 percent of the upper watershed is climax, old-growth forest. Most of the impervious surface in the watershed occurs in its lower, urbanized portions.

While processes other than stream flow remain relatively intact in the upper watershed, the lower watershed has been extensively altered. The City of Seattle's Chester Morse Masonry Dam diverts a substantial portion of the flow for water supply and also alters the flood cycle and other aspects of the natural hydrology. Management of the river channel for navigation and flood prevention included extensive diking. Today, 64 percent of the lower Cedar is modified on at least one bank, a condition which, in conjunction with decreased flows, has artificially narrowed the river's historic average width of approximately 250 feet to 110 feet. This alteration has resulted in a 56 percent reduction in water surface area (i.e., available instream aquatic habitat; Kerwin 2001).

The loss of floodplain and riparian connectivity in the lower 17 miles of the Cedar River has also affected storage of water, sediment, and contaminants, simplifying instream habitat. Channelization and the disconnection of the Cedar River floodplain for flood control have restricted access to and decreased the amount of channel and frequently-inundated habitat, preventing salmonids and other organisms dependent on these riverine wetlands from accessing this natural habitat. This is of particular concern for Chinook stream-type history salmon, which use these streams and associated habitat to rear juvenile salmonids. More Chinook now exhibit a lake-type life history and use Lake Washington for rearing prior to smoltification and outmigration. Many of the Chinook leaving the Cedar River and entering the Lake are relatively young and require shallow habitat in the Lake for a critical life cycle stage (Remers 1971; Grassley 2000).

Channelization has also limited availability and recycling of spawning gravels. The toes of steep banks in the middle watershed are important remaining sources of coarse substrate, and high quality pool habitat is often associated with these features. Efforts to stabilize these areas to protect human development limits gravel and LWD inputs, degrading local habitat quality (Kerwin 2001).

Tributaries in the lower watershed have also experienced altered stormflows as a result of human development. Many of these streams flow through relatively steep and confined valleys or ravines, and altered hydrology has caused incision and increased sediment inputs, channelization, riparian disconnection, and habitat simplification. Kerwin (2001) also identifies Rock Creek as having impaired summer baseflow due to water withdrawals.

Residential land-uses and associated actions such as sewage line installations and road crossings have also contributed to increased sedimentation and degraded water quality in tributary basins. Nutrient inputs and fecal coliform are likely contributed by a variety of sources, including agriculture, livestock waste, residential fertilizers, and septic systems. Urban and industrial land-uses in the Cities of Renton and Kent are the primary sources of toxins such as PCBs and other chemicals associated with oil and gas on roads.

Water quality impairments in the Cedar River Watershed are summarized in Table 3-2.

Table 3-2. 2004 Ecology 303(d) Water Quality Impairments in Cedar River Watershed

Water Body	Impairments	Areas of Concern
Cedar River	Fecal coliform, temperature	DO, fecal coliform, temperature, pH
Rock Creek		DO, pH
Taylor Creek		Bioassessment
Rex River		pH

Source: Ecology (2008)

Due to land use changes within the Cedar River floodplain, many high process areas are have been impacted by flood control structures as well as urban and rural development. There are a variety of areas upstream from Renton where relatively minor restoration efforts can provide restoration of important ecological processes. A variety of such locations are identified in salmon recovery and floodplain management plans.

At river mile (RM) 4.7 a landslide and flood damage has degraded a side channel restoration area in Ron Regis Park for which the city is considering mitigation (WIRA8). At RM 4.4-5.8, Buck's Curve Levee limits floodplain connectivity and off channel habitat vegetation and channel diversity necessary for riparian habitat. Cavanaugh Pond (RM 6.5, wetlands #6) is a 44 acre Natural Area on Cedar River's right bank where invasive species make it difficult to establish native forest that provides the most effective riparian habitat (KC SMP). Also at RM 6.5, the Herzman Levee separates the Cedar River from its floodplain, thereby eliminating off-channel habitat (KC SMP). The Cook/Jefferies and Progressive Investment levees are located between RM 7.3-8.2 and have resulted in a confined channel structure and a disconnected sub-channel just below Cook/Jefferies levee (WIRA8, KC SMP). The Lion's Club side channel (RM 10.2-12.7) is currently dry but was once a side channel and floodplain which provided spawning gravels for Chinook rearing habitat (KC DNR).

The Cedar Grove Road SE crossing (RM 11) and Cedar Mountain Revetment (RM 10.9) create channel confinement and little floodplain access. Rainbow Bend and McDonald Levees (RM 11.5, 11.7) disconnect the Cedar River from its natural floodplain, increasing channel velocities via downstream channel confinement (KC SMP). Due to increasing floodwaters, Cedar Grove Mobile Home Park at RM 11 is at high-risk for flooding and is currently a relocation candidate for the King County Flood Control District.

At the Taylor Creek/Cedar River confluence (RM 12.7), there is a shortage of LWD which aids in fish passage (WIRA8). Petersen Creek (RM 14.1) and Rock Creek (RM 18.2) require LWD for fish passage as well along with floodplain restoration at the mouth and prospective rock structures to create flow refuge for juvenile fish (WIRA8).

At RM 20.1, the Wingert Side Channel lacks vegetation and LWD to help with riparian habitat. Revetments at RM 20.2 and 20.6 are preventing a vegetation buffer from developing along riparian areas, minimizing salmon habitat. At RM 21.5, Wetland 69 is disconnected to Cedar River, preventing salmonid access (KC SMP).

In addition to these locations identified for specific actions, there are a range of man-made structures and land use changes that affect ecological processes areas of less intense rural development that are candidates for restoration or rehabilitation.

3.3.2.3 May Creek

The WRIA 8 Salmon and Steelhead Limiting Factors Report (Kerwin 2001) provides limited information about the May Creek Watershed. Information presented below relies heavily on the May Creek Basin Action Plan adopted in 2001 by King County and the City (Renton, 2001).

The May Creek watershed drains approximately 14 mi^2. The seven-mile-long stream originates on the forested slopes of Cougar and Squak Mountains and the Renton Plateau. Tributaries originating high in the watershed flow onto a relatively large floodplain with a low gradient (May Valley). As the gradient increases downstream, and the stream cuts through relatively erosion-resistant deposits to form a canyon before opening up into the Lake Washington valley.

Upper reaches of the May Creek watershed lie mostly outside urbanized land and UGAs. Historic logging, farming, and mining practices have been replaced by residential development in tributary basins. The tributary basins still contain a significant amount of open space; residential land and hobby farms in May Valley; and urban development in the City of Newcastle and in the City, downstream of the May Creek gorge.

Effective impervious area was reported as seven percent in 2001 and is expected to increase to twelve percent as a result of future build-out (Renton 2001). Kerwin (2000) estimated total impervious area to be between eleven to sixteen percent at the time of the report. Most of the impervious area is located within the City, in lowland areas, the Honey Creek drainage on the East Renton plateau, and in incorporated areas of Newcastle to the north. The wide floodplain in May Valley provides substantial storage during flood events and is extremely important for attenuating stormflows downstream in lowland reaches. Peak flows have increased flooding in the valley, but filling and straightline drainage have reduced flood storage capacity (Renton 2001).

Increased peak flows and riparian degradation have contributed to increased stream channelization and bank erosion in the upper watershed. Eroded sediment is deposited in May Valley and in May Creek itself, diminishing flood storage potential and degrading substrate quality. Storage of sediment in floodplain areas is desirable for improving sediment and water quality processes, but has negative feedback effects on hydrology. Increased peak flows have also caused increased bank erosion in the May Creek gorge and lowland tributaries.

Sediment acts as a vehicle for delivery of phosphorous and toxins to water bodies in the absence of storage areas between the source and receiving body. Despite the documented presence of increased sediment loading in May Creek, a water quality trend analysis conducted by King County showed decreased total suspended solids and phosphates from the period of 1979-2004 (King County 2008). Monitoring results indicated increased conductivity and ammonia-nitrogen concentrations over the same period. May Creek is also becoming more acidic, but remains unimpaired as defined by state water quality criteria.[17] Water quality in Honeydew Creek and May Creek is listed as impaired by fecal coliform on the state 303(d) listings. This suggests increased inputs of waste from livestock and septic systems on the upland plateau.

Degraded riparian habitat also affects instream structure and physical habitat; Kerwin (2000) gives May Creek a 'poor' rating for instream habitat. The rating system addresses criteria such as pools and LWD density. Existing riparian corridors are primarily deciduous and early-seral conifer forests; some have been deforested as a result of land-use encroachment. This is particularly true in May Valley, which is mostly open space, having been converted from forest to pasture.

Water quality is also suffering as a result of increasingly high temperatures (King County 2008). This may be partially due to climate change, which is increasing ambient air temperature and altering snow to rain precipitation ratios. However, non-functional riparian conditions (Kerwin 2001), low flow impairments associated with groundwater recharge, and flow alterations indicate that localized factors may also contribute to increased temperatures and, consequently, deteriorating water quality.

3.3.2.4 Green River

The Green River watershed is 566 mi^2, and the river itself stretches 93 miles. The river originates in the Cascade Mountain crest near Stampede Pass. From its source, the river flows west and northwest through narrow valleys and steeply-sloped terrain before reaching Howard Hanson Dam at river mile (RM) 64.5. At RM 61.0, the river flows past the Tacoma drinking water diversion (RM 61.0), which marks the beginning of a 14.5-mile gorge, through which the river drains prior to entering the Puget Lowlands. Downstream of the gorge, agriculture, forestry, and rural residences are common. The river transitions to more urbanized settings downstream of Soos Creek and Highway 18 (RM 33.7).

At approximately RM 11, the Green River passes to the west of the City of Renton. None of the river channel lies with City limits, but some floodway and jurisdictional shoreline as well as significant portions of tributary basins such as the Black River/Springbrook Creek are located within City limits. WRIA 9 has an estimated population of 564,000. Although 90 percent of the population lives within lowland UGAs, there is almost no residential land-use or population within the Black River/Springbook Creek basins in the City.

Land-use in the upper watershed has had a low-to moderate-impact on rain-on-snow zones and sediment inputs via mass wasting. However, the impact of these alterations is overridden by the Howard Hanson Dam actions which artificially stores both water and sediment and interrupts replenishment of course gravels and LWD. Tributaries upstream of the dam are likely affected to some extent by land-uses, but those effects are not translated downstream.

Land-uses downstream in upland plateaus and lowlands have historically included ditch construction, channelization, and flood control dikes and levees that have degraded mechanisms for water storage. Normally, the patchwork mosaic of aquatic habitats associated with a large river system and active floodplain sustain aquatic habitat during low flows and attenuate flow during storm events. Alterations that have disconnected the floodplain have concentrated discharge in the Green River channel and substantially reduced off-channel aquatic habitat quantity, quality, and availability.

Nowhere is impact of river channelization more apparent than in the Duwamish estuary, which is an extremely important habitat for rearing and outmigrating juvenile salmonids. More than

[17] Water Quality Standards for Surface Waters of the State of Washington, WAC 173-201A

97 percent of the historic estuarine mudflats, marshes, and forested riparian swamps comprising the estuary have been destroyed by river channelization, ditching, draining, dredging, and filling.

In addition, urbanization in upland plateaus drained by tributaries and in the lower reaches of the Green River decreases groundwater recharge and increases stormflows. These alterations occur to a lesser extent between urban areas and mountains, where impervious area remains low, but forest cover loss is moderate, particularly on the mainstem floodplain.

Downstream of the gorge, mass wasting of sedimentary bedrock adjacent to the river and disturbed areas associated with land-use contributes predominately fine sediment to the river. In addition, floodplain disconnection has reduced the storage capacity for fine sediments, which instead accumulate in the main channel, increasing the propensity for substrate armoring and generally degrading substrate quality.

Increased fine sediment loading degrades physical habitat quality and provides a vehicle for adsorbed contaminants such as phosphorus and chemical toxins to enter water bodies. This input mechanism is particularly important in urban residential and industrial areas (Table 3-3), found primarily in the lower watershed where toxin sources and other water quality impairments are present in high densities. In the Duwamish Waterway this mechanism is further exacerbated by contribution of adjacent land uses to chemical toxins, including several Brownfields and Superfund sites.

Lakes, wetlands, and floodplains provide storage for fine sediment and adsorbed contaminants to precipitate instead of entering streams. Numerous lakes in the middle watershed are listed as impaired for phosphorus, implying the potential or existence of eutrophication and change to macrophytic community structure and productivity. Wetland and floodplain functions are highly degraded in this area, limiting the potential for water quality improvement.

Agricultural land-use may also contribute phosphorus through sediment pathways as well as nitrogen. Rural residential areas and hobby farms found between the gorge and urban areas and on tributary plateaus are sources of nitrogen and pathogen contamination associated with human and animal waste, but roads in these and other areas provide pathways for both adsorbed and water-soluble materials such as automobile residues to enter water bodies. Pathogen contamination is a serious problem throughout the entire lower watershed and Duwamish Waterway.

Low dissolved oxygen (DO) concentrations are associated with the presence of fecal coliform. Dissolved oxygen is also highly correlated with temperature, which has become a major limiting factor for salmonids in the watershed (Kerwin and Nelson 2000). Sources of temperature increases include impaired hydrologic and riparian processes. Reduced low flows in the summer resulting from snowmelt storage and reduced groundwater inputs act in concert with decreased shading from deforested riparian areas to warm surface waters.

Table 3-3. 2004 Ecology 303(d) Water Quality Impairments in WRIA 9

Water Body	Category 2[a] Impairments	Category 5[b] Impairments
Duwamish Waterway	Temperature, DO, pH, phthalate	PCB, PAH, DO, pH, DDT[a], DDD[a], Alpha BHC[a], DDE[a]
Lower Green River		Temperature, fecal coliform, DO
Black River/Springbrook	DO, Temperature, pH Mercury, Copper, Bis(2-ethylhexyl)phthalate	DO, Fecal Coliform
Mill Creek	Temperature	Fecal coliform, DO
Hill (Mill) Creek		Temperature, fecal coliform, DO, copper
Mullen Slough	Temperature	Fecal coliform, DO
Star Lake		Fecal coliform
Panther Lake	Phosphorus	
Tributary 09.0046		Fecal coliform, DO
Big Soos Creek	Temperature, mercury, ammonia-N, pH	Fecal coliform, DO
Little Soos Creek	pH	Temperature
Meridian Lake		Fecal coliform, phosphorus
Jenkins Creek		Fecal coliform
Covington Creek		Fecal coliform
Morton Lake		Fecal coliform
Sawyer Lake		Fecal coliform, phosphorus
Doloff Lake		Fecal coliform
Middle Green River	pH	Fecal coliform, temperature
Crisp Creek	Mercury, DO	Fecal coliform
Newaukum Creek	pH	Fecal, DO, copper
Upper Green River (Howard Hanson Dam tailout)	Toxaphene, Endrin	Temperature
Gale Creek		Temperature
Smay Creek	Dieldrin	

[a] Attaining some of the designated uses; no use is threatened; and insufficient or no data and information are available to determine if the remaining uses are attained or threatened.

[b] Impaired for one or more designated uses by a pollutant(s) and requires a total maximum daily load (TMDL).

The loss of intact riparian corridors has also limited biotic uptake of contaminants and deposition of fine sediment that would improve ecological function. In addition, there are impacts to instream habitat complexity and sediment storage potential from the lack of LWD (and recruitment potential).

3.3.2.5 Black River/Springbrook Creek

Black River/Springbrook Creek flows into the Green River at RM 11. As indicated in Section 3.1.2, the Black River previously was part of the Cedar River system and conveyed the flows of the Cedar River to the Green River. In 1916, Cedar River discharge diverted from the Black River to Lake Washington; due to lowering of Lake Washington. The portions of the Black River east of Springbrook Creek dried up or were filled and the Black River is simply an archaic label for the downstream reaches of the Springbrook Creek system.

Its headwaters are located on the eastern plateau between the Green and Cedar Rivers. Almost all of this watershed is highly urbanized. Since the 1930s, the stream has been maintained in an artificial channel by King County Drainage District #1 (KCDD #1), which owns the Springbrook Creek right-of-way (ROW). The KCDD #1 maintained the channel initially for agricultural drainage and currently maintains it for stormwater conveyance (Map 9b). The channelized stream resulted in substantial alteration to hydrologic patterns. Adjacent development generally extends to the edge of the levees that define the streambank, limiting the width of the riparian corridor. Existing riparian vegetation, if present, is typically herb, shrubs, and deciduous trees. Alterations in the basin are extensive and ecological function is highly impaired (Table 3-4).

Upland areas are underlain by varying layers of geologic deposits that force groundwater to move horizontally and produce seeps along the upland/floodplain transition, supporting a shallow floodplain aquifer and the summer baseflow in Springbrook Creek. The large amount of impervious surface limits infiltration potential and redirects water overland, increasing peak flows. Loss of floodplain connectivity and conversion of associated wetlands to impervious surfaces limits flood attenuation capacity and increases peak flows (Kerwin and Nelson 2001).

Land conversion has also resulted in increased inputs of fine sediment. Within the stream is very low gradient and these increased inputs of fine sediment exacerbate poor substrate conditions in reaches that have naturally high fine content. Conversion of an extensive network of historic riparian wetlands and loss of floodplain connectivity limits the potential for both sediment storage and water quality improvement. Industrial land-uses adjacent to the water body and its tributaries have resulted in high concentrations of metals, including copper, lead, zinc, and cadmium (Kerwin and Nelson 2001). The lack of a functional riparian corridor exacerbates sediment and water quality impairments and contributes to the overall lack of instream habitat complexity. Eighty-three percent of Springbrook Creek is glide habitat, while only three percent is pool habitat (Harza 1995 as cited in Kerwin and Nelson 2001). Some gravel still exists in the Hill Creek tributary upstream of the Green River floodplain; these reaches are a high priority for protection (Kerwin and Nelson 2001).

Black River/Springbrook Creek contributes to water quality impairment in the mainstem Green/Duwamish River, but the contribution is effectively proportionate to flow and the relative level of degradation. Black River/Springbrook Creek mean annual flow for the period of record is approximately 10 cfs, a small fraction of the Green River's mean annual flow of 1530 cfs (USGS 2008).

Table 3-4. Watershed Conditions in Black River and Springbrook Creek

Stream	Floodplain	Instream	LWD	Streambed	Sediment	Riparian	WQ	Hydrology	Biotic
Black River	F	F	P	P	P	P	P	P	P
Springbrook Creek	F	P	P	P	P	P	P	P	P
Hill Creek	F	P	P	P	P	P	P	P	NA
Hill Creek tributary	F	P	P	P	P	ND	P	P	NA
Garrison Ck.	F	ND	ND	ND	ND	ND		P	NA

F = Fair; P = Poor; ND = No data; NA = not applicable

Source: Kerwin and Nelson (2001)

3.3.2.6 Lake Desire

Lake Desire located five miles southeast of the City in a Potential Annexation Area. The lake's surface area is 72 acres, and it is relatively shallow, reaching a maximum depth of 21 feet. Land-use in the basin and along the shoreline is low- and medium-density residential (Map 8a). King County manages the Lake Desire/Spring Lake Park to the east and southeast of the lake. Rainbow trout (*O. mykiss*), yellow perch, pumpkinseed sunfish (*Lepomis gibbosus*) and largemouth bass are known to inhabit the lake.

Lake Desire is currently eutrophic (characterized by high amounts of aquatic algae and low DO levels; King County Natural Resources and Parks 2008c). Lake Desire is listed as impaired for phosphorus on Ecology's 2004 303(d) list of impaired water bodies (Ecology 2008). The exotic species Eurasian water milfoil has been observed. These conditions are likely the result of landscaping and septic waste associated with adjacent residential land-uses. The sport-fish species in the lake are non-native and have likely had some influence on natural biotic interactions in the lake.

King County completed a management plan for the lake in the mid-1990s and received partial funding to implement management actions, including an artificial aeration facility to improve DO concentrations. The plan included a clause requiring the removal of 50 percent of all phosphorus in stormwater runoff attributed to new development (King County Department of Natural Resources [DNR] 1996).

4. SHORELINE INVENTORY AND ANALYSIS

4.1 LAKE WASHINGTON

4.1.1 General Conditions

Lake Washington is designated a shoreline of statewide significance by the Shoreline Management Act (RCW 90.58.020) because it is greater than 1,000 acres in size. As such, the Lake is recognized for its value to all citizens of the State of Washington and should be managed to ensure that this value is sustained.

Renton contains about six miles of Lake Washington shoreline which has been partitioned into eleven reaches (See Map 1b). These reaches are based primarily on land-use characteristics and, to a lesser extent, on ecological functions (ecological function is similar across reaches).

4.1.2 Hydrological and Biological Resources

As indicated above in Section 3.3.2.1, the Lake Washington basin includes most of the 692 square miles contained in WRIA 8 and is populated by approximately 1.4 million people (Kerwin 2001). The City of Renton lies at the south end of Lake Washington and contains approximately 21 square miles, or three percent, of the total watershed and less than one-half percent of the total watershed population. Lake Washington has 80 miles of shoreline, about six of which are within the Renton planning area, or about eight percent.

In 1916, the Lake Washington Ship Canal was constructed and the Cedar River was re-routed to the lower end of Lake Washington, permanently altering the Lake's ecology and shoreline, and decreasing the range of annual lake level fluctuations. Prior to 1916, the Lake's depth would fluctuate as much as seven feet during flood events (Chrzastowski 1983). The lowering of the Lake's elevation and the management of the inflow/outflow regime has represented the most significant alteration to the waterbody's ecosystem processes, having direct hydrologic effects and effects that interact with other processes. Lowering the Lake's level reduced its total surface area and shoreline length, converted its edges from gradual to steep declines, and converted much of the near shore from wetland habitat into deep water habitat (Kerwin 2001). More than 1,300 acres of shallow water habitat, acres which once provided habitat for juvenile salmonids and associated ecological communities, were lost in the process (Kerwin 2001).

The U.S. Army Corps of Engineers USACE regulates water level fluctuations in the Lake in a manner that reduces the range of fluctuation so that the range is about one-third of the natural fluctuation, and also reverses the seasonal fluctuation pattern (natural lake levels are lowest during the summer; the opposite is true today). This altered hydrology creates some benefits for lakeshore property owners and recreational users, but has impacted the Lake's ecology. Changes in the natural hydrologic regime affect native fish, wildlife, and plant species adapted to natural fluctuations of the lake level.

In 1896, it was observed that 'the shore of Lake Washington is not well adapted to collecting with a seine' (Evermann and Meek 1897). This was probably due to the abundant submerged woody debris, and dense underbrush, small trees, and tule (hardstem bulrush) that fringed the shoreline. The vegetation community of hardstem bulrush and willow that naturally dominates the Lake's shoreline has largely been replaced with development, hard-armoring, landscaped yards, and artificially continuous lakefront parcels. The loss of natural shoreline has reduced complex shoreline features such as overhanging and emergent vegetation, woody debris (especially fallen trees with branches and/or rootwads intact), and gravel/cobble beaches. Riparian vegetation has responded to the altered hydrologic regime and led to a change in relative proportion of aquatic plants adapted to shallow water habitats, and terrestrial vegetation adapted to drier summer conditions.

The majority of Lake Washington's shoreline is now urban residential (Weitkamp et al. 2000). There are also a few commercial and industrial developments on the shoreline, the largest of which are located in Kenmore at the north end, at downtown Kirkland and Carillon Point in Kirkland on the east side, in the Leschi area of Seattle on the west side, and at the Boeing Company and Renton Municipal Airport at the south end.

Analysis of aerial photos indicates that in 1999, approximately 59 percent of the vegetation cover adjacent to the shoreline was lawn/garden, with slightly less than 20 percent natural shrub-scrub, forested, or herbaceous habitat. About 70 percent of the shoreline was bulkheaded, which is similar to the 67 percent in the City of Renton.

There were 2,737 docks on the Lake in 1999, an increase of almost 50 percent from 1960. Renton, has the lowest number of docks per mile of shoreline, a fact that reflects the large proportion of public and industrial shoreline ownership of City shoreline (Tolt 2001).

4.1.2.1 Tributaries and Associated Wetlands

Seven tributaries drain to Lake Washington within the City's municipal limits. To the north of May Creek there are two unnamed tributaries (Map 1b). Both May Creek and the Cedar River are high-quality waters that support anadromous salmonids. Between them lie Kennydale Creek and John Creek. Another ephemeral stream that does not support salmonids lies west of the Cedar River.

Wetlands are identified on the Lake Washington shoreline in the National Wetlands Inventory (NWI, USFWS 2008) north of May Creek. In Reach C there is a small wetland area on the Seahawks Training Center and a large wetland complex along the lake margins of the Quendall Terminals property. In Gene Coulon Park there are apparent wetland complexes near the mouth of Kennydale Creek and slightly further south and north of the driveway turnaround. The public harbor lands adjacent to the Boeing site may contain some wetlands. It is probably that there are small pockets of wetland on properties not managed as lawn.

4.1.2.2 Fish and Wildlife Presence

Most species of anadromous salmon and trout native to the west coast of North America including Chinook, coho (*O. kisutch*), sockeye, chum, and pink salmon, and steelhead (*O. mykiss*), coastal cutthroat (*O. clarkiclarki*), and bull trout (*Salvelinus confluentus*; native char) can be found in WRIAs 8 (Cedar River; see Map 5a) and 9 (Green River; see Map 5b). There are also resident cutthroat and rainbow trout (same species as steelhead) living in these waters, although the rainbow trout in Lake Washington appear to be descendents of non-native hatchery stock (Kerwin 2001).

The Lake Washington watershed supports three Chinook stocks, including Issaquah Creek, north Lake Washington tributaries, and Cedar River, all of which are listed as Threatened under the Endangered Species Act (ESA; Kerwin 2001). Chinook produced in the Cedar River are those most likely to use shoreline habitat within the City. Coho and Sockeye salmon produced in the Cedar River are also present along the City's shorelines.

Additional salmonids associated with the Lake enter from May Creek, located between Reaches C and D, and the Cedar River, which discharges into the Lake between Reaches I and J (Maps 5a and 5b; WDFW SaSI 2008).

Cedar River salmonids found in Lake Washington include:

- Lake Washington/Sammamish Tributary Sockeye (Healthy Status)
- Lake Washington Beach Spawning Sockeye (Depressed Status)
- Summer/Fall Cedar Chinook (Depressed Status)
- Cedar Sockeye (Depressed Status)
- Cedar Coho (Depressed Status)
- Lake Washington Winter Steelhead (Critical Status)

May Creek species include the following (Status):

- Lake Washington Beach Spawning Sockeye (Depressed Status)
- Lake Washington Winter Steelhead (Critical Status)
- Lake Washington/Sammamish Tributary Sockeye (Healthy Status)

Young fall Chinook produced in the Cedar River migrate into Lake Washington from late winter through summer (February-July) Juvenile Chinook outmigrate into Lake Washington from the Cedar River until the end of July (Walter 2009). The early migrants are small fry (~1.2 inches) that remain in very shallow water (~1 ft) along the lake's shorelines (Tabor et al. 2004). These fry prefer gently sloping sand to gravel (swimming beach) shorelines with some overhanging or submerged vegetation or fine woody debris that provides cover from avian or fish predators. The young Chinook remain in the shoreline habitat eating mostly epibenthic insects (chironomid pupae; Kohler et al. 2006). As they grow, they gradually move into deeper water (2-3 feet deep), but remain along the shorelines. By June, the young Chinook have grown large enough to move into deeper waters and begin to feed on planktonic prey, specifically zooplankton (*Daphnia* spp; Kohler et al. 2006). Recent warming trends in Lake Washington may affect *Daphnia* abundance (Hampton 2006).

Early juvenile Chinook are highly-dependent on shallow shoreline habitat during their early rearing in the Lake. Larger juvenile Chinook migrating to the Lake in late spring are less dependent on shorelines and move rapidly through the Lake to the Ship Canal and Puget Sound. All Chinook are listed as threatened under the ESA as part of the Puget Sound evolutionarily significant unit (ESU). Surveys of juvenile Chinook presence in Lake Washington indicate that the density of fish fall off with distance from the mouth of the Cedar River as indicated in Figure 4-1. This may indicate that the first several miles of shallow habitat along the shoreline in the City are of disproportionate importance for this critical lifecycle stage (Tabor 2008).

The Cedar River produces some Coho salmon (Kiyohara and Volkhardt 2007). Coho generally spend their first year of life rearing in freshwater then migrate through Lake Washington as smolts to the ocean during early summer (April-July) in their second year of life.

Two extant Sockeye stocks within the Lake Washington watershed are distinguished by geographic and reproductive separation and by genetic differences. The Cedar River/Issaquah Creek/Lake Washington beach spawning population appears to be derived from the Baker Lake, Skagit River stock (Hendry et al. 1996) planted in Lake Washington in the 1930s and 1940s. The Bear Creek-Cottage Creek population is distinct from the non-native populations and is apparently predominantly of native ancestry (Hendy et al. 1996). Lake Washington

Sockeye are depressed (Salmon and Steelhead Stock Inventory [SASSI] 1984) but are not ESA-listed.

Numerous Sockeye spawn in the Cedar River. Young Sockeye may rear in the river for some time prior to migrating to Lake Washington for additional rearing. Sockeye also spawn in shallow water (1-20 ft deep) at many locations along Lake Washington's shorelines. No accurate surveys of current spawning locations are available, and it is unknown if any of the other streams within the City of Renton historically supported Sockeye.

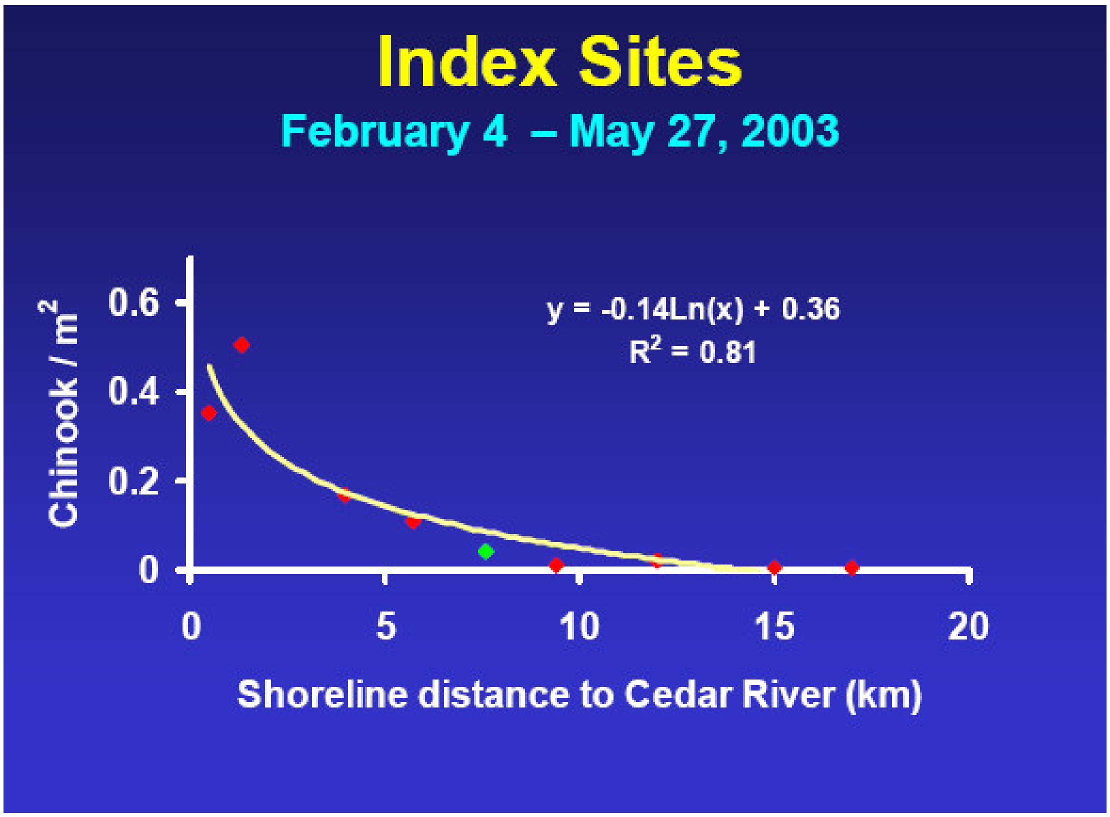

Figure 4-1. Density of Chinook Population, Distance from Mouth of Cedar River

Beach spawning by sockeye salmon in Lakes Washington is believed to have been much more common in the past than at present. Relatively few sockeye are believed to currently spawn in beach areas compared to stream spawning fish. Boat surveys are only conducted one or two times annually by the Washington Department of Fish and Wildlife (WDFW) at several index areas in Lake Washington including Coleman Point in Renton (at about N. 30th Street). Relatively few adult sockeye are observed during these index surveys, and few lake residents report sightings of spawning sockeye in nearshore areas, although such survey methods are recognized as lacking in rigor. When sockeye salmon are observed spawning in beaches, they typically utilize gently sloping beach or nearshore areas with small gravel substrates (Foley pers. comm. 2009). Bulkheads at the shoreline can discourage beach and nearshore spawning because the bulkhead typically eliminates the gradually sloping shoreline gradient and shallow water habitat that sockeye favor for spawning. Bulkheads also may block groundwater upwelling that supplies dissolved oxygen and therefore reduce spawning success (Foley, pers. comm. 2009). Juvenile Sockeye are primarily planktivorous feeders residing in the lake's water column away from the shoreline (Eggers et al. 1978). Lake

Washington Sockeye undergo very substantial variations in adult return numbers that support in-lake fisheries during some years.

Two stocks of resident Sockeye that do not migrate to saltwater, known as Kokanee, have also been identified in the Lake Washington watershed. An early-run stock once resided in Issaquah Creek but is now believed to be functionally extinct. Another stock currently uses larger tributaries of the Sammamish River such as Bear Creek. Lake Sammamish Kokanee are currently being considered for listing under ESA. Kokanee have not been to occur in the City's streams or use its shorelines.

Puget Sound Steelhead is listed as threatened under the ESA. The Cedar River population is of natural origin. Populations of winter-run Steelhead have undergone steep declines in abundance recently. According to the stock status report for 2002, steelhead numbers are below 100. Steelhead redd counts in the Cedar River have declined to fewer than a dozen in recent years. This represents is a critical issue for steelhead survival. (Walters 2009) Winter-run or ocean maturing Steelhead return as adults to the tributaries of Puget Sound from December to April (Puget Sound Biological Review Team [PSBRT] 2005). Spawning occurs from January to mid-June with peak spawning occurring from mid-April through May. Steelhead reproduce in the Cedar River as well as several other areas within the Lake Washington watershed. According to the stock status report for 2002, steelhead numbers are below 100. Steelhead redd counts in the Cedar River have declined to fewer than a dozen in recent years. This represents is a critical issue for steelhead survival. (Walters 2009) Commonly, young Steelhead rear within the River and its tributaries for two or more years before beginning their migration to the ocean through Lake Washington. Seaward migration occurs principally from April to mid-May (PSBRT 2005). At an age of 2 years or more, the juvenile Steelhead migrants tend to be substantially larger than other salmon migrants (two-year-old wild smolts are 140-160 mm in length [Wydoski and Whitney 1979]). They tend to migrate rather rapidly, and are not dependent on shallow shoreline habitat.

The inshore migration pattern of Steelhead in Puget Sound is not well understood; it is generally thought that Steelhead smolts move quickly offshore (PSBRT 2005). At this time, very little information is known about juvenile Steelhead use of Lake Washington. Washington Department of Fish and Wildlife (WDFW) researchers have captured Steelhead migrants in the Cedar River from mid-April through the end of May (Volkhardt et al. 2006), but if or how they use the nearshore area of the Lake has not yet been determined. Critical Habitat designation is currently under development by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) with a proposal expected in the future (NMFS 2007).

Rainbow trout in Lake Washington appear to be descendents of previously planted, hatchery-produced trout. Young rainbow trout are primarily planktivores, feeding predominately on *Daphnia*, but become piscivorous as they grow larger (Beauchamp 1990). Rainbow trout are predators of juvenile Chinook in the Cedar River (Tabor et al. 2004). Both rainbow and cutthroat been identified as a substantial predators of juvenile Chinook in Lake Washington (Tabor et al. 2005).

In recent years, the cutthroat trout population has been increasing in Lake Washington (Fresh 1994). Juvenile cutthroat begin feeding on invertebrates and switch to fish as they grow larger (Beauchamp et al. 2006). Young cutthroat move from tributaries into Lake Washington at about age two and feed increasingly on fish as they grow in size (Nowak et al. 2005). Cutthroat range throughout the Lake and do not establish home ranges. They forage in littoral areas primarily in the spring during daylight hours (Nowack and Quinn 2002).

Bull trout is listed as threatened under the ESA. A resident population of bull trout occurs in Chester Morse Lake (Cedar River; Reiser et al. 1997). These bull trout spawn in the upper Cedar River and rear in Chester Morse Lake. Small numbers of sub-adult and adult bull trout have been observed in Lake Washington over a number of years. These bull trout appear to be migrants into Lake Washington from other river basins or fish that have passed downstream from Chester Morse Dam and become isolated from their population.

Other native fish species found in the Lake Washington watershed include western brook lamprey (*Lampetra richardsoni*), river lamprey (*Lampetra auresii*), peamouth chub (*Mylocheilus caurinus)*, largescale sucker (*Catostomus snyderi*), pygmy whitefish (*Prosopium coulteri*), northern pikeminnow (*P. oregonsensis*), speckled dace (*Rhinichthys osculus*), and five species of sculpin (*Cottus sp.*). Numerous species of nonnative fish also occur, including yellow perch, brown bullhead, black crappie (*Pomoxis nigromaculatus*), pumpkinseed sunfish, and largemouth and smallmouth bass, which can be significant predators of juvenile salmonids (Kerwin 2001; Parametrix 2000). Many of these species are found in the Green River. Although many may occur in shallow shoreline areas, none are known to require specific shoreline habitat characteristics.

Priority habitat data from WDFW identifies two osprey (*Pandion haliaetus*) nests north of May Creek (Reaches A and B) and a bald eagle (*Haliaeetus leucocephalus*) nest in the vicinity of the Cedar River (Reaches I and J; Map 5c: Wildlife). These species and others use shoreline areas for foraging and cover.

4.1.2.3 Nearshore and Riparian Habitat

Nearshore and riparian habitat along the Lake Washington shoreline is severely altered in nearly every reach, within the City of Renton and outside of the City limits. Residential and commercial development, including bulkheads, docks, paved areas, and landscaped yards have adversely modified most of the Lake Washington shoreline habitat. However, many of these shoreline areas continue to provide shallow water habitat at the toe of bulkheads, and some locations that do not have bulkheads. Narrow docks perpendicular to the shorelines do not appear to impede shoreline migration of young Chinook, but the fish appear to migrate around wider structures where they occur in shallow water (less than three feet deep).

A Muckleshoot Tribe representative has indicated that the deeper nearshore habitats with rocky substrates and without vegetation appear to be preferred by smallmouth and largemouth bass. These bass may also be keying in on overwater coverage and pilings as ambush habitat. Because there is an abundance of these habitat types in the shoreline, predation opportunities that would not exist historically are likely increasing today (Walter 2009).

Shallow water habitat along these shorelines provides important rearing habitat for juvenile Chinook as they slowly migrate from the Cedar River and rear along Lake Washington's shorelines. Those areas closest to the River are most important for this rearing function because the smallest Chinook use gently sloping, shallow shorelines for weeks to months as they gradually move away from the river mouth. Although riparian vegetation increases the refuge and prey production functions for this habitat, the shallow beaches support rearing juvenile Chinook in the absence of natural riparian vegetation (Tabor 2008).

Reaches A and B from the Bellevue City limits to the Seahawks Training Center are largely single family and have shorelines modified by bulkheads and docks throughout these reaches. Natural riparian vegetation has been removed, and only a few residences have trees or shrubs that support natural habitat functions. However, many of the bulkheads do not extend far into the lake, leaving a small amount of shallow water habitat used by juvenile Chinook and other shallow water fishes. Most of the docks in these reaches are narrow at the shorelines;

consequently, most are unlikely to impede shoreline migration of young Chinook. The alteration of the shoreline, including the effects of bulkheads on the nearshore substrate and on interflow, of bulkheads and *ornamental vegetation on shade and shallow water temperature, the loss or degradation of t*he normal food web in the aquatic and adjacent upland areas, the discharge of chemical load to the lake from overspray and runoff of fertilizers, herbicides, and pesticides from maintenance of ornamental vegetation as well as the effects of over-water structures all may be considered to continue adverse effects on aquatic organisms and continue to contribute to the decline of ecological functions.

Reach C immediately north of May Creek includes shoreline has undergone restoration recently, in conjunction with redevelopment projects at the Seahawks Training Center and the former Barbee Mill Sawmill. The Seahawks Training Center has included some replanting of the lakeside as well as preservation of a lakeside wetland. The central property in this area, the Quendall Terminals site has the most natural vegetation and wetland complexes along the shoreline. This site, however is contaminated from past creosote treatment facilities. It is unknown what affect cleanup of the site may have on the site.

At the southern portion of the reach at the Barbee Mill subdivision the public aquatic lands have been reshaped into more natural beach configuration including LWD installed for shoreline protection and to provide in-water structure for fish habitat and upland areas have been replanted. This area has been withdrawn for leasing by the Department of Natural Resources (DNR) who is responsible for management of public aquatic lands due to the value of the restored area as habitat, to give the process or restoration time to become established and to benefit the public by providing the opportunity to observe, stusy, enjoy, and promote the understanding of the restoration of such systems (DNR 2006). Some overhanging vegetation and deciduous tree cover does exist, and can be expected to improve as plantings mature.

The May Creek delta was dredged in the past to provide log storage for Barbee Mill. Dredging is no longer needed for log storage and flood conveyance in May Creek for the recent subdivision was designed presuming reformation of the delta in the future (Renton 2003). Sediment from May Creek will reform a natural delta and provides natural shallow water habitat as well as wetlands and eventually additional upland riparian habitat. It is likely to be ten to fifteen years before delta formation is readily apparent, but after filling in deeper areas dredged in the past the area will fill rapidly thereafter and provide complex high quality aquatic and riparian habitat. As the delta expands, it is likely to provide an important habitat for Steelhead, cutthroat trout, Chinook, coho, and sockeye salmon. The May Creek Basin Action Plan calls for enhancement of the delta if Barbee Mill operations should cease to provide a unique opportunity to establish an improved habitat area (Renton, King County 2001).

The effects of current use and future redevelopment on ecological functions are uncertain. Current vegetation buffers are very limited and are likely to provide limited function. Areas with bulkheads will have adverse impacts on nearshore areas. Areas where ornamental vegetation is maintained next to the lake will continue to have adverse impacts water temperature and water quality. The development of over water structures may affect predator balance, and maintenance of access to docks in the area of delta formation may interfere with the range of beneficial effects from reestablishment of that natural process and ecosystem complex.

In Reaches D and E, single-family residential use has removed almost all natural vegetative cover but shallow shoreline habitat of some value still exists, providing Chinook rearing habitat. The northerly portion of these reaches will benefit from May Creek delta deposition.

The area around Coleman Point provides important shallow water habitat and has been identified and monitored as a sockeye spanning location by WDFW (Foley 2009).

The alteration of the shoreline environment and the continuing effects of bulkheads, ornamental vegetation and over water structures will have continuing adverse effects on natural processes important to a variety of aquatic species including substrate character, interflow, shallow water temperature, the normal food web, discharge of chemicals to the lake and predator balance and therefore are likely to continue to contribute to trends of the decline of ecological functions.

Reaches F and G include Gene Coulon Park. The north end of the park (Reach F) provides functional riparian habitat through abundant native trees and shrubs at the shoreline and relatively natural sloping substrate without bulkheading. Although much of the upland area is lawn and there is some impervious area from trails and vehicular access, the area provides a range of natural riparian functions and some overhanging cover and has shallow water habitat conditions suitable for use by very young salmon.

In the southern, more developed portion of Gene Coulon Park (Reach G) riparian vegetation along a substantial area of the shoreline has been removed. However, the gently-sloping sand-gravel beaches, such as at the swimming beach and boat launch, do provide shallow water habitat heavily used by very young Chinook. The peninsula at the south end of Gene Coulon Park provides some natural riparian vegetation overhanging the shoreline.

The effects of varying extents of alteration of the shoreline environment in this area on the trends observed throughout the lake of decline of key species are uncertain. High populations of juvenile salmonids have been observed, but it is not known whether these populations are due to proximity to the Cedar River or to the quality of the habitat. In general, the extent to which the shoreline has been altered is likely to have continuing impacts on substrate character, interflow, shallow water temperature, the normal food web, discharge of chemicals to the lake, and predator balance however at a much lower level than more intensely developed area. Reach F also has high potential for improving habitat values through changes in management to emphasize native shoreline vegetation cover.

Reach H between Gene Coulon Park and the Boeing Company has a modified shoreline that provides little habitat value. This reach is the location of the former Sheffelton Steam Plant and is currently undergoing redevelopment as the Southport mixed use development. The shoreline in this area consists of vertical bulkheads adjacent to relatively deep substrates. Riparian vegetation is absent. The absence of shallow (less than three-foot-deep) habitat severely limits the functions provided to young Chinook in this reach; however this relatively short stretch likely does not substantially impede fish movement along the shore with the current absence of over-water structures. The sediment from Johns Creek immediately to the north may change the depth and character of substrate over time as deposition continues.

R**each I** between Southport and the Cedar River is a highly modified shoreline which provides little habitat value. Most of the shoreline in this area has steep or vertical hard substrates including the former Sheffelton Steam Plant flume and bulkheads at the Boeing facility. Where present, the riparian vegetation is dominated by shrubs and scrub. The absence of shallow habitat limits the functions provided to young Chinook in this reaches. About a third of this reach is public harbor land with upland vegetation bounded by the sheet pile former outfall from the Sheffelton power generation plant.

The continuing cumulative adverse effects of bulkheads and the lack of native vegetation on near-shore processes important to a variety of aquatic species including substrate character, interflow, shallow water temperature, and the food web may be reduced in the future by the recent proposal by the DNR to remove the sheet-pile outfall structure and restore the nearshore as part of an aquatic restoration program (DNR 2009) and by expansion of the Cedar River delta.

The Cedar River delta provides a large amount of rapidly-developing, natural shallow water habitat in Lake Washington. In the past, the mouth of the River was periodically dredged for flood control. The City has no plans to dredge the delta in the future for flood control (Straka 2008). However, some dredging for the Municipal Airport float plane dock is proposed in order to restore water depths. Natural processes at the delta have not yet developed any areas of sufficient elevation to support riparian vegetation, but they have created a large amount of shallow water habitat where young Chinook first enter the lake. Further natural expansion of the delta is likely to eventually prove a very productive complex of shallow aquatic habitat, wetlands and uplands that together will provide for the transition between the river environment and lake environment that is critical to a number of species, including salmon.

Reach J contains the Renton Municipal Airport immediately east of the Cedar River Delta. The airport has managed riparian vegetation to avoid bird nesting or roosting to prevent collisions with airplanes (Straka 2008). However, some LWD has been retained along the end of the runway to enhance shoreline habitat. The Airport's shoreline is currently lined with either concrete and rock rubble or vertical sheet pile bulkheads. The character of the shoreline contributes to continuing cumulative adverse effects of bulkheads and the lack of native vegetation on near-shore processes important to a variety of aquatic species including substrate character, interflow, shallow water temperature, and the food web. Airport authorities are currently working with resource agencies and the Muckleshoot Tribe to develop additional improvements to the shoreline and delta habitat associated with reconfiguration of the float plane dock.

Reach K, located east of the Airport, is primarily multi-family and single-family residential with very limited natural vegetation. Bulkheads, residential structures, and landscaped areas dominate the shoreline. Much of the shoreline is also devoted by docks and moored vessels. Many bulkheads in this reach extend to water depths of several feet at the low lake elevation, thereby eliminating much shallow shoreline habitat.

Existing development, ongoing landscaping practices, and shoreline modification, including installation of bank features and new overwater structures, have contributed to the conditions in Lake Washington that have to continue to degrade. It is possible that the current structures and vegetation management practices contribute to continuing trends of declines of indicator species such as Chinook salmon and steelhead.

4.1.2.4 Terrestrial Wildlife Habitat

In addition to providing key habitat inputs for aquatic species, riparian areas provide habitat to terrestrial wildlife species. In natural conditions, wildlife species abundance and diversity are higher in native riparian-wetland habitat than in other habitat types because these areas provide:

- A diversity of habitat including structural features and plant species;
- Edge habitat where two or more types of habitat adjoin;
- Varied food sources; and
- A predictable water source (Kauffman, et al. 2001; O'Connell et al. 2000).

The productivity of wildlife habitat is related to its size and complexity. High-quality habitat allows an area to provide for the necessary lifecycle stages of a species including reproduction, sustenance (forage), refuge from predators, genetic diversity, and the opportunity to avoid or recover from catastrophic events such as disease that can decimate local populations. In landscapes altered by human development and activities, habitat patch size and complexity and linkages are key factors that allow species to find enough area for needed functions and move from one area to another. In areas where habitats are fragmented and isolated by development and roads, linkages that connect larger tracts of more diverse habitat are especially important (Adams 1994).

In an urbanized setting like Renton, riparian areas provide habitat for species if they are connected by linkages or corridors that allow species to move between areas to forage, breed, and complete other functional or seasonal needs. The characteristics of a species are critical to how they use habitat. Birds, for example, can fly to a variety of habitat patches, but may need protected nesting areas that are not affected by predation or nest parasitism (Robbins 1991). Small species, such as amphibians, reptiles, and small mammals, may be able to maintain populations within a small area, but are subject to catastrophic declines from disease, parasites, or predation that may depopulate a habitat patch. Without adequate linkages, these potential habitats may not be re-colonized, leading to an overall decline in species populations and diversity (Ferguson 2001). Substantial habitat patches with linkages are relatively rare on the Lake Washington shoreline in the City.

Sensitive wildlife species occurring in the area include osprey and bald eagle (Map 5c). Osprey species have two documented occurrences in Reach C and one documented occurrence adjacent to Reach G of the Lake. Although osprey may roost or nest inland from a lake shoreline, they will use open water and shoreline areas to forage. Bald eagle nesting areas are not recorded along the Lake Washington shoreline within the City or County PAAs. However, there is one nesting area documented along Reach A of the Black River and one documented along Reach D of the Cedar River. Bald eagles have a large home range and likely use the Lake's shoreline for perching and foraging opportunities. Presence of overwater structures serve as obstacles to shoreline access and clear views of potential prey. The area around the Lake is highly-developed, with a dominant land cover of medium- and high-density land-use (Map 8e) and a recorded presence of 143 private dock structures along the City and County PAA shoreline. These shoreline modifications eliminate potential roosting and nesting habitat for osprey, bald eagles, and other birds of prey along and directly adjacent to the shoreline.

Shorelines in Reaches A and B are extensively modified by residential development and the removal of natural riparian vegetation. Ornamental trees and shrubs may provide some terrestrial wildlife functions, but do not provide a continuous vegetated corridor. The right of way of the Burlington Northern Santa Fe (BNSF) railway does provide a continuous corridor parallel to the shoreline that is largely vegetated on each side of the tracks and connects to habitat patches. The effectiveness of this linkage is limited on the east, however, by Interstate 405, a formidable barrier. Habitat patches along the railroad ROW are relatively small. The narrow width of the private roadway serving this area is a relatively permeable barrier to movement from the shoreline to the railroad ROW to the east, but the presence of houses and ornamental vegetation likely reduces the likelihood that terrestrial species would be attracted to most of the shoreline.

Reach C contains the Seattle Seahawks Football Training Facility, Quendall Terminals, a Superfund site, and a recently completed residential subdivision. This corridor has some native riparian vegetation and a narrow corridor of restored shoreline vegetation along the Seahawks center and the residential development. The May Creek corridor provides a linkage between this area and a relatively complex vegetated community to the east, but the culvert crossing under Interstate 405 is a substantial barrier to wildlife movement.

In Reaches D and E, single-family residential development has removed almost all natural vegetative cover, but continues to provide limited habitat value, primarily for birds. Although the BNSF railroad adjoins this area to the east, there is little vegetation along the ROW to provide a corridor for animal movement.

The north end of Gene Coulon Park (Reach F) provides a variety of functional habitat. Although much of the Park is lawn, there are areas of native vegetation, most notably at the mouth of John's Creek. An almost continuous corridor of tree cover is present along the adjacent railroad. John's Creek provides a linkage to a narrow riparian corridor to the east, but movement is limited by Lake Washington Boulevard. Linkages to other habitat areas are limited. The south end of Gene Coulon Park is devoted to more intensive recreation use and provides little continuous shoreline vegetation

Reaches H and I, between Gene Coulon Park and the Cedar River delta, include some areas of riparian vegetation north of the Boeing property on state aquatic lands, but this habitat is isolated from potential linkages by impervious-surfaced, bank-armored shorelines on either side. The Cedar River delta provides little terrestrial habitat, but may support some riparian vegetation in the area as delta deposition continues. It is connected to parkland along the east bank of the Cedar River and a narrow area of altered vegetation adjacent to the Renton Municipal Airport. Overall, habitat potential in this area is very limited.

The Renton Municipal Airport (Reach J), immediately east of the Cedar River, has managed shoreline vegetation in the past to prevent establishment of habitat for birds that might interfere with airplanes. Most of the shoreline is rock rubble or vertical sheet pile bulkheads, which provides little or no terrestrial habitat.

East of the Airport (Reach K), natural vegetation is not present where bulkheads, residential structures, and landscaped areas predominate on the shoreline. There is a potential linkage via a narrow riparian corridor to the east, but movement is limited by Lake Washington Boulevard (a four-lane major arterial).

4.1.2.5 Critical Areas

The City has identified and mapped landslide and erosion hazard areas along portions of Reach E and in two short sections of Reach F (see Map 4a). These areas have steep slopes that are relatively short. Other sections of shoreline from Reach J east are flat and were likely historic wetlands (see Map 4b). The City has determined many shoreline areas that have been filled to be seismic hazard areas because of their susceptibility to soil liquefaction (see Map 4c).

USACE manages the water level in Lake Washington, thus, no flood hazard areas are present on the shoreline except for the Cedar River delta. Aquifer recharge areas lie mostly outside of the Lake Washington shoreline (see Map 4c). A large aquifer recharge area extends from Lake Washington Boulevard to the City limits, adjacent to Reaches E and F (see Map 4c). Small portions of this recharge area are within 200 feet of the Lake Washington OHWM and thus lie within jurisdictional shoreline.

4.1.2.6 Shoreline Modifications

Conditions and processes throughout the Lake Washington system have been significantly modified over the last 100 years. Some of the larger-scale modifications include:

- In 1916, when the Ship Canal was opened and the Cedar River re-routed to Lake Washington, the Lake's ecology and shoreline were permanently altered. These actions lowered the Lake's level by 10 feet, exposed 5.4 square kilometers of previously shallow water habitat, reduced the Lake's surface area by seven percent, decreased the shoreline length by about 12.8 percent, and eliminated much of the lake's wetlands (King County et al., 2005).

- Water level fluctuations in the Ship Canal, maintained by the USACE, range up to 3 feet; the water surface elevation ranges between 20 and 23 feet. The minimum water elevation is maintained during winter, in reverse of a natural annual hydro-cycle. This allows for annual maintenance of docks and other structures; minimizes damage during winter storms; and provides flood storage volume (USACE 2004c).
- Increased stormwater runoff and input of sediment and other pollutants into the Lake due to changes in land use and increased development.

In addition, there has been extensive localized modification of the shoreline. Modifications include shoreline armoring (concrete bulkheads, riprap, and other 'hard' structures intended to stabilize the shoreline and minimize erosion), overwater structures (e.g., marinas, residential docks, and piers), and dredging and filling (Figures 4.2, 4-3, 4-4, and 4-5).

Figure 4-2. Typical Shoreline Armoring with Rock

Figure 4-3. Typical Shoreline Armoring with Rock and Cement

Figure 4-4. Typical Residential Dock on Lake Washington

Figure 4-5. Dock with Grated Deck

Shoreline modifications associated with residential development are most prevalent in Reaches D and E, which are characterized by single-family residential development with associated bulkheads, riprap, docks, and boat lifts. In contrast, the lakeshore in Reaches F and G (low density residential land-use) and Reach J (industrial land-use) contain shoreline areas that vary from natural or restored shoreline to a combination of hard armoring with some vegetated shoreline for an overall less-modified physical environment (see Tables 4-1, 4-2, and 4-3, below in this section). A synthesized table with percent modifications by Reach and category can be found in Appendix A.

Table 4-1. Shoreline Modifications by Reach on Lake Washington Shoreline Parcels

Shoreline Modifications	A	B	C	D	E	F	G	H	I	J	K	Total
Total number of shoreline parcels	3	13	5	33	25	1	1	3	3	1	99	187
Parcels with hard shoreline armoring	1	7		31	22			3	1		91	156
Parcels with commercial/industrial shoreline									1			1
Parcels with combination of hard shoreline armoring and natural vegetation		3	2	1	2		1			1	1	11
Parcels with moderate shoreline armoring (no bulkhead, some veg., and/or areas of natural veg.)	2	1									3	6
Parcels with natural (unmodified) shoreline		2	3	1					1		4	11
Parcels with restored shoreline (large woody debris present)					1	1						2
Total	**3**	**13**	**5**	**33**	**25**	**1**	**1**	**3**	**3**	**1**	**99**	**187**

Thirteen parcels along the Lake's shoreline are either unmodified or restored (Table 4-1, Maps 11b and 11e). The restored parcels include one single-family residential property on Reach E and Gene Coulon Park on Reaches F and G. Gene Coulon Park contains a combination of restored shoreline, vegetated shoreline, and some armored shoreline. Kennydale Beach Park (Reach D) contains a combination of modified and natural shoreline. Overall, 174 parcels contain some level of 'hard' armoring. This includes major commercial/industrial parcels (e.g., the Renton Boeing Plant) and private residential properties with hard armoring, moderate armoring, natural shoreline, or a combination thereof. Parcels that are completely armored with concrete bulkheads, rocks, or similar structures comprise 67 percent of the Lake Washington shoreline. The majority of these parcels occur in D, E, and K, which are developed for single or single/multi-family residential use.

Armored shorelines create undesirable habitat conditions for native fish including several species of native salmon that use the Lake for rearing and migration. Bulkheads, for example, eliminate and displace shoreline vegetation that is critical for fish and other wildlife. Hard armoring also displaces available water refugia and foraging habitat for juvenile salmonids. Bulkheads may alter the slope, configuration, and/or substrate composition of the shoreline by obstructing upland sediment supply and increasing erosion on neighboring properties lacking bulkheads. The increased wave erosion from waves reflected from bulkheads may also affect substrate composition and the slope of the nearshore (Kahler 2000). This increased erosion on neighboring properties is likely associated with increases in bulkhead construction, partly explaining why the cumulative number of bulkheads on the Lake is so high (Walter 2009). Losses of wetland and shoreline vegetation in the Lake is likely attributable to filling and shoreline development (Grassley 2000).

Piers and docks may alter natural predator-prey interactions and create favorable conditions for predator fish species (e.g., sculpin, smallmouth bass). Juvenile salmon require sufficient cover such as brush piles, rootwads, and undercut banks to avoid predators. Developed lakes containing piers and docks in place of natural cover may result in an increased likelihood for predation.

Table 4-2. Overwater Structures by Reach on Lake Washington Shoreline Parcels

Overwater Structure	A	B	C	D	E	F	G	H	I	J	K	Total

Parcels with float/buoy present		1	1	1		1					2	**6**
Parcels with joint use residential dock		3		1	1			2			6	**13**
Parcels with major boat ramp facility				2						1		**3**
Parcels with no private residential dock	2	1	3	5	3			1	2		15	**32**
Parcels with other dock structures (not defined above)				2					1		2	**5**
Parcels with private boat lift	1	2		8	15						20	**46**
Parcels with private boat lift and covered dock		2		11	5						16	**34**
Parcels with private residential dock		2		3	1						26	**32**
Parcels with private, covered residential dock		1	1								11	**13**
Parcels with public marina		1					1				1	**3**
Total	**3**	**13**	**5**	**33**	**25**	**1**	**1**	**3**	**3**	**1**	**99**	**187**

Source: ESA Adolfson 2008

There are 143 private docks associated with shoreline parcels along the Lake, most of which occur on Reaches D (25 total), E (22 total), and K (81 total; Table 4-2, Maps 11b and 11e). Only 32 parcels along the shoreline lack a private residential dock. This includes the relatively unaltered reaches F and G, which have one float/buoy structure and one public marina, respectively (Maps 11b and 11c). Properties without docks that contain only floats/buoys, boat ramp structures, or public marinas comprise a small portion of the shoreline (12 parcels total). Twenty-five percent of the parcels have private boat lifts; parcels with both a private boat lift and a covered dock make up 18 percent of the shoreline. In addition, 13 parcels contain joint-use residential docks.

Overwater structures along the shoreline have several effects on fish, wildlife, and aquatic vegetation. Docks and piers create artificial shading which reduces the amount of light available for phytoplankton and aquatic macrophytes. This may decrease primary productivity and fish and invertebrate species diversity (Kahler 2001). Studies indicate that predators linger near piers and other structures, which affects prey population levels. Although these data are somewhat inconclusive, bass (particularly smallmouth bass) have been documented to thrive in lakes with highly modified shorelines while salmonids and other fish species decline. This suggests that predator species have an advantage over prey fish species in structurally-altered environments (Kahler 2000).

Historically, docks and piers were constructed of chemically-treated (e.g. creosote-coated) wood, which introduces polycyclic aromatic hydrocarbons (PAHs) and heavy metals to the aquatic environment. These preservatives can leach into the water column and become toxic to aquatic organisms. The number of docks made of treated wood is unknown. It is expected that most of the newly-constructed docks along the Lake's shoreline areas are made of alternative, neutral materials that are less harmful to the environment and to aquatic organisms.

Noise and pile driving associated with construction of dock, pier, and bulkhead construction can also affect fish and wildlife. Noise and vibration caused by driving in marine environments has been found to startle juvenile salmonids (Feist et al. 1996). These effects likely occur in lake environments and the surrounding area as well, although additional data are needed. Modern technology commonly required by permitting agencies for new in-water construction (e.g., vibratory pile-driving, acoustic wave-reducing bubble curtains, etc.) reduces or mitigates these effects. Individual residential docks are exempt from these requirements.

Shore-spawning Sockeye salmon species, which occur in the Lake, are particularly susceptible to dock, pier, and bulkhead construction and shoreline alterations that modify any of the following:

- Habitat structure
- Substrate
- Hydrologic patterns
- Water temperature
- Water quality

Sockeye spawning areas may become degraded due to several factors, including scoured streambed material, fine sediment that has eroded from building sites, and surface water runoff from impervious surface that is transported into the Lake. Vulnerable beach spawning areas include nearshore substrates that receive spring-fed upwelling and alluvial fans at stream mouths (Parametrix 2003).

Sensitive wildlife species occurring in the area include osprey and bald eagle. The presence of overwater structures serve as obstacles to shoreline access and clear views of potential prey. The area around the Lake is highly-developed, with a dominant land cover of medium- and high-density land-use (Map 8e) and a recorded presence of 143 private dock structures along the City and County PAA shoreline. These shoreline modifications eliminate potential roosting and nesting habitat for osprey, bald eagles, and other birds of prey along and directly adjacent to the shoreline. Potential prey species (e.g., salmonids and other fish present in the Lake) may also provide insufficient nutrition or harmful agents due to water quality issues in the lake (Map 7).

Table 4-3. Building Setbacks by Reach on Lake Washington Shoreline Parcels

Setback	A	B	C	D	E	F	G	H	I	J	K	Total
Parcels with building setback between 20 and 50 feet		6	1	3	7	1					51	69
Parcels with building setback greater than 50 feet		1	1		6				1	1	11	21
Parcels with building setback of less than 20 feet	1	6	1	28	12		1	1			34	84
Parcels with no structure present	2		2	2				2	2		3	13
Total	**3**	**13**	**5**	**33**	**25**	**1**	**1**	**3**	**3**	**1**	**99**	**187**

Source: ESA Adolfson 2008

According to aerial photograph analysis, approximately 45 percent of the Lake's shoreline parcels within the City and County PAA shoreline contain structures with a building setback of less than 20 feet. Most of the parcels with this setback width were located along the three most developed reaches: D, E, and K. Approximately 37 percent of the shoreline parcels have building setbacks of 20 to 50 feet. Reach K contained most of the parcels characterized by this building setback width, which probably reflects the greater depth of the lots in that area. Development patterns that include structures close to a lake's shoreline can negatively affect the shoreline and water quality in several ways. Development located on sloped terrain can contribute to erosion and overland stormwater runoff, which deposits sediments that act as a vehicle for delivery of phosphorous and toxins to water bodies, soluble pollutants, and excess nutrients into a lake. A vegetated buffer area less than 50 feet in length is of limited effectiveness in removing sediments and nutrients. Stormwater from driveways can contain high levels of petrochemicals from fuel and lubricants. If the area between buildings is devoted to lawn, fertilizers, pesticides, and herbicides can be washed into a lake by rainfall. If applied in a volatized form, fertilizers may drift into the water during application (May 1997). The National Marine Fisheries Service (NMFS) has determined that carbaryl and carbofuran, common chemicals in lawn care products jeopardize salmon due to effects on the central nervous system (NMFS 2009). Location of lawns or ornamental vegetation adjacent to the shoreline also limits the potential for native vegetation to provide shade, cover, and food resources for aquatic species (Collins 1995).

Human activity along a shoreline, particularly when associated with overwater structures such as docks and piers, can disturb fish and wildlife species that use shoreline habitat for cover, foraging, and/or nesting areas (Brazner 1997). Wave action and water level fluctuations in the Lake (generally ranging from elevation 20 to 23 feet) together with the proximity of structures close to the shoreline has led to shoreline stabilization on most shoreline property with hard armoring. Hard armoring prevents the recruitment of native sediments to the Lake, which prevents the replenishment of a natural shallow nearshore and beach environment, which together with a vegetated environment and absorbs and dissipates wave energy at the shoreline. Instead, armoring reflects wave energy at the shoreline, creating a high-energy environment in the Lake and resulting in gradient and substrate features that are less favorable for spawning and rearing habitat (Kahler 2000).

Recent permit activity in the City and along Lake Washington is shown in Figures 6 and 6a. Of special interest to Lake Washington is the large amount of single family redevelopment and remodeling of existing lakeshore lots. In many cases, this redevelopment and remodeling has not been accompanied by replacement of existing shoreline stabilization or docks. This may represent the loss of opportunity to apply future revisions to shoreline regulations to these sites, until such time as those facilities age or need to be replaced, separate from changes in the primary structures.

4.1.2.7 Other Natural Features

The City has identified and mapped landslide hazard areas along most of Reaches E and F and two short sections of Reach F (see Map 4a). Reach F also contains a short stretch of shoreline susceptible to surface erosion (see Map 4a). These areas generally have steep slopes. Other sections of shoreline from Reach J east are flat and were likely historic wetlands (see Map 4b). The City has determined many of these areas to be seismic hazards because of their susceptibility to soil liquefaction.

The USACE manages the water level in the Lake, thus except for the Cedar River delta, no flood hazard areas are present in the shoreline. Aquifer recharge areas lie mostly outside of the Lake's shoreline (see Map 4c). A large aquifer recharge area extends from Lake Washington Boulevard to the City limits, adjacent to Reaches E and F (see Map 4c). Small portions of this area are within 200 feet of the Lake Washington OHWM and thus lie within jurisdictional shoreline.

The sensitive natural areas described above are regulated under Renton Critical Areas Ordinance[18] , as other similar areas in other shorelines described below.

[18] Renton Municipal Code, 4-3-050

4.1.3 Built Environment

4.1.3.1 Existing and Planned Land-Use

Existing Land-Use

According to King County Assessor's (2008) parcel data, land-use along the Lake's shoreline is a mix of residential, industrial, parks, recreation and open space, and vacant areas. In general, low-density residential development (23 percent) and vacant land (22 percent) are the dominant land-uses along the shoreline. Industrial lands and parks, recreation, and open space lands make up 15 percent each. Lands dedicated to transportation comprise approximately 20 percent of the shoreline planning area.

- **Reach A:** is entirely single-family residential and lies between the Bellevue city limits and Renton city limits
- **Reach B:** includes mostly single-family use with one large shoreline multi-family development
- **Reach C:** includes the recently constructed Seattle Seahawks headquarters and training facility at the northernmost portion of the Reach. The Quendall Terminals south of the Seahawks headquarters has been designated a Superfund site by the U.S. Environmental Protection Agency (EPA). The site is being studied by the EPA to determine the extent of the pollution caused by coal tar and creosote application and the best course of remedial action. A residential development is currently being built on the southernmost portion of reach on the former Barbee Mill site (City of Renton website 2008b).
- **Reaches D and E:** are primarily single-family residential and contain the City's Kennydale Beach Park on the shoreline. Lots in Reach E are generally of greater depth, and can be accessed via Mountain View Avenue.
- **Reaches F and G:** are composed entirely of Gene Coulon Park and are categorized as parks, recreation, and open space.
- **Reach H:** is composed of vacant (66 percent) and multi-family residential (33 percent) land-uses. Southport, a mixed-use development under construction, will be located along the entire length of the reach. The first phase, completed in 2002, is a 395-unit apartment building. The second, final phase is the development of three nine-story office buildings, a hotel, and several restaurants to create a Lake-front promenade (City of Renton website 2008c).
- **Reach I:** contains the Renton Boeing Plant, classified as an industrial land-use, which is located just east of the mouth of Cedar River. A portion of the shoreline in this reach is public aquatic lands located waterward of the inner harbor line.
- **Reach J:** contains the Renton Municipal Airport, which is classified as government/institutional. A portion of the Airport's shoreline frontage is considered a water-dependent use since it includes a seaplane dock on the Lake.
- **Reach K:** contains a portion the West Hill PAA and extends from the current City limits to the Seattle city limits and is primarily single-family residential with some multi-family residential within the 200 foot zone of shoreline jurisdiction. However, the majority of this development does not directly front the water. There is a small mobile home park in the easterly portion of this Reach.

Planned Land-Use

Within the City limits the City's Zoning and Comprehensive Plan land-use designations along the Lake are mainly residential and mixed-use. Reach B has low density residential (82 percent) and mixed-use (18 percent) comprehensive plan and zoning designations. All of Reaches C, H and I are designated with mixed-use comprehensive plan and zoning designations. Reaches D through G are designated with low density residential zones and comprehensive plan designations. Reach J has industrial designations (City of Renton 2008b).

Outside City limits in Reaches A and K, the City and County have designated most of the land as low density residential. Reach A is located in unincorporated King County. According to County Zoning and Land Use Maps, Reach A is entirely designated as low density residential. Reach K is located in the City's PAA. The County has zoned most of Reach K as low density residential (77 percent) with the remaining as multi-family residential (23 percent). The City's Comprehensive Plan has designated more land as low density residential (96 percent). The remaining is designated as multi-family residential (four percent; King County Department of Development and Environmental Services [DDES] 2006 and 2008; City of Renton 2008b).

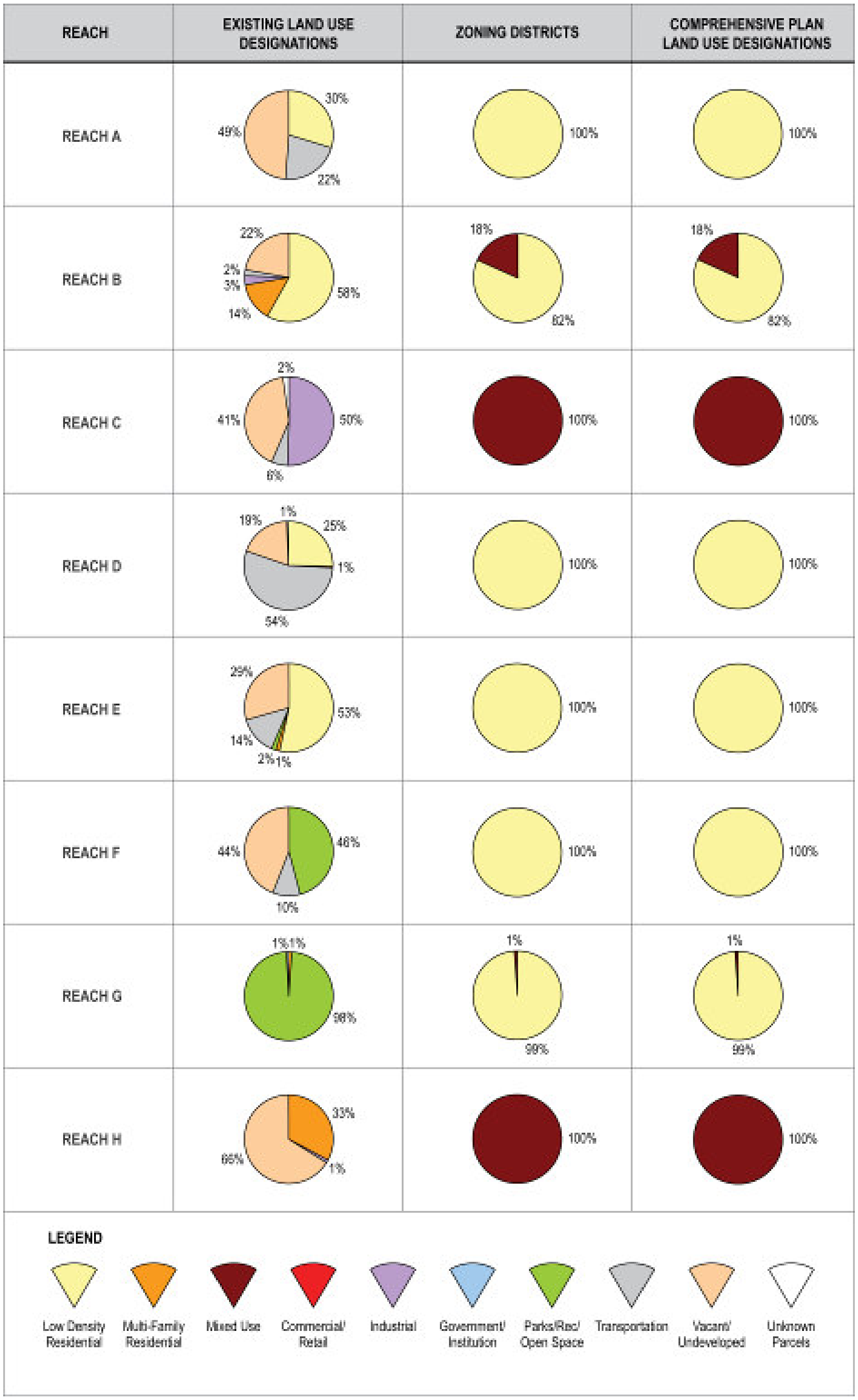

Figure 4-6 Percentages of Existing, Allowed and Planned Land Use by Reach in the Lake Washington Shoreline Planning Area

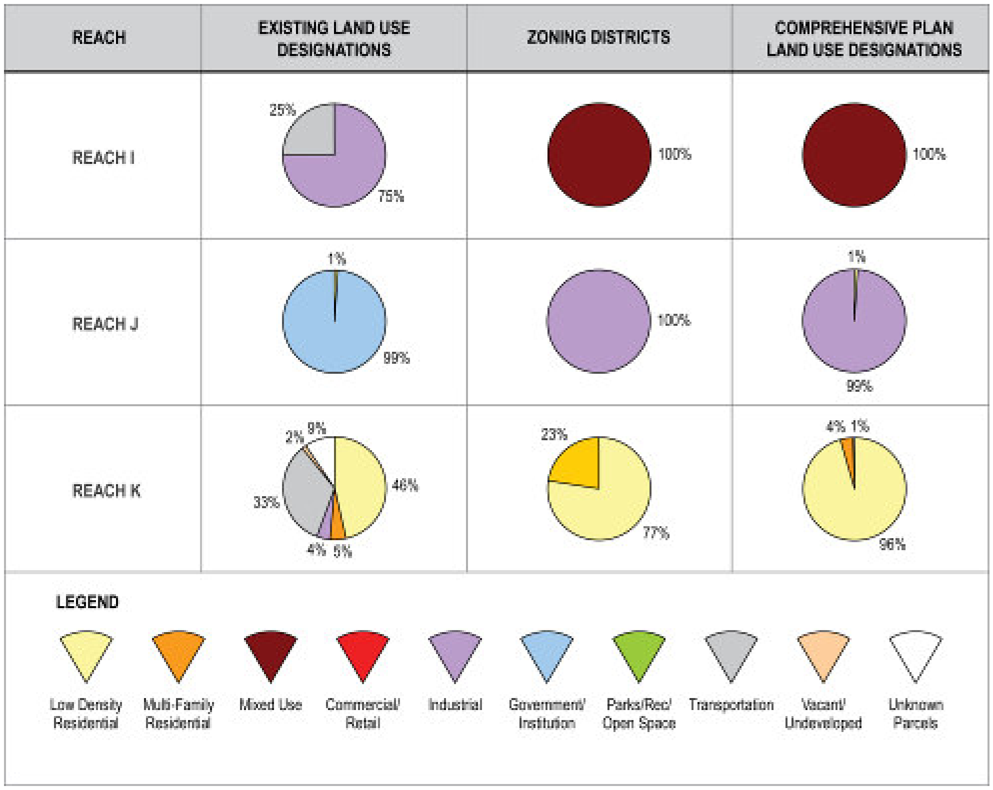

Figure 4-6 Percentages of Existing, Allowed and Planned Land Use by Reach in the Lake Washington Shoreline Planning Area (Continued)

Figure 4-6 shows the percentage of existing land-use, zoning, and comprehensive plan land-use designations for each of the Lake's shoreline reaches. The City of Renton does not designate ROW with a zoning district or a comprehensive plan designation. Therefore, the values in the columns *Zoning Districts* and *Comprehensive Plan Land Use Designations* do not include ROW. Transportation is an existing land-use in many shoreline planning areas, a transportation category was included in the Existing Land Use Designations analysis. The total amount of transportation per reach was determined using King County Assessor's data, which is available at the parcel level and provides transportation land-use information where parcels categorized as ROW are typically included in the railroad ROW. City staff performed additional calculations of existing roadway ROW by reach.

Existing water-oriented uses are located in Reaches D, F, G, and J. These include parks that provide physical access to the Lake and a Renton Municipal Airport with a seaplane dock. Kennydale Beach Park (Reach D) and Gene Coulon Park (along the entire length of Reaches F and G) provide public access to the shoreline via beach access, public piers, and boat launches. The Renton Municipal Airport (along the entire length of Reach J) is a water-dependent use since it has a seaplane dock. Water-oriented opportunities beyond these uses are limited because of the existing single-family residential development.

Undeveloped or Vacant Lands

Table 4-4 provides the percentage of parcels identified as undeveloped and the undeveloped area by reach. Reach A, in unincorporated King County, is almost 50 percent undeveloped. The percentages of undeveloped area shown in the table for Reach C and H will decrease once construction of Port Quendall and Southport are completed. The remaining undeveloped areas are located in reaches designated for single-family residential development (Reaches B, D, and E). The Washington DNR owns approximately 3 acres of vacant, undeveloped land which is located outside the City limits, near Reach I (King County Department of Assessments website 2008). The property is not accessible to the public.

Table 4-4. Existing Development of Waterfront Parcels along Lake Washington

Reach	# of Lots	% Undeveloped Lots	% Undeveloped Area
A	35	6%	49%
B	19	16%	22%
C	37	5%	41%
D	56	9%	19%
E	34	9%	29%
F	5	60%	44%
G	4	50%	0%
H	4	50%	66%
I	4	50%	0%
J	3	0%	0%
K	160	9%	2%

Source: King County 2008; City of Renton 2008a

4.1.3.2 Impervious Areas

Impervious areas were analyzed based on the City's GIS layer. Impervious areas include roadways, buildings, and other paved surfaces (such as driveways and parking lots) that prevent the natural penetration of water into the soil. Impervious surfaces affect infiltration, create more stormwater runoff, increase the rate of runoff, and alter runoff timing. Table 4-5 shows the total impervious area and percent of impervious area for each reach within the Lake's shoreline planning area. Only buildings and public ROWs are included as impervious areas. The entire ROW was included in the calculation for roadway impervious surfaces. This was derived from the same calculation conducted by the City of Renton for the transportation land use category. Building impervious area was calculated based on 2005 aerial photos. The data does not include other types of paved surfaces.

Table 4-5. Impervious Surface in Lake Washington Shoreline Planning Area
Includes only the area within the Shoreline Planning Area

Reach	Total Acres	Impervious Area (Acres)	Percent Impervious	Roadway % of Total Impervious areas	Building % of Total Impervious Areas
A	11	4	33%	65%	35%
B	6	2	24%	9%	91%
C	18	2	10%	58%	42%
D	13	5	37%	78%	22%
E	12	3	27%	52%	48%
F	15	1	10%	98%	2%
G	13	1	5%	18%	82%
H	3	0	0%	0%	100%
I	12	3	26%	96%	4%
J	2	0.31	17%	0%	100%
K	27	12	43%	78%	22%

Source: City of Renton,2005

Since the data does not reflect driveways, parking lots, and recent construction, the amount of impervious surface for some reaches is larger than shown in the table. The following is a list of sites that contribute additional impervious area:

- Construction of Seattle Seahawks Headquarters and training facility and Conner Homes in Reach C
- Parking lot pavement in Gene Coulon Park in Reaches F and G
- Southport Phase 2 construction in Reach H
- Pavement at Boeing Airplane Company in Reach I
- Pavement at Renton Municipal Airport in Reach J

The remaining reaches (A, B, D, E, and K) have established single- and multi-family residential land-uses with impervious surface amounts that are more accurately reflected in the table. In general, the percentage of impervious area is an indicator of development density and intensity. Overall in the City, approximately 25 percent of the Lake's shoreline planning area is impervious due to public ROWs and buildings.

4.1.3.3 Floodplain and Channel Migration

Lake Washington does not have a floodplain because the lake elevation is controlled by the US Army Corps of Engineers at the Hiram Chittenden Dam and Locks.

Lakes are not considered to have channels or channel migration zones.

4.1.3.4 Public Access

Currently, the public has visual and/or physical access to the Lake's shoreline at the following locations (City of Renton Parks and Recreation website 2008):

- The **Seahawks Football Training Facility** provides a small shoreline access and viewing area near the north end of the property in Reach C.
- The **Barbee Mill** residential development provides public access to a small area of public aquatic lands waterward of the inner harbor line in Reach C.

- **Kennydale Beach Park** is a 1.8-acre park located in Reach D with a sandy beach that provides physical access to the Lake. The Park also has a pier, log boom, playground, picnic tables, restrooms, and benches.
- **Gene Coulon Memorial Beach Park** is a 55-acre park located in Reaches F and G. It has passive and active water-oriented and non-water-oriented recreation opportunities including eight boat-launch lanes, playground equipment, tennis courts, horseshoe pits, sand volleyball courts, picnic shelters, an interpretive botanical walk, fishing pier, food concessions, parking lots, and 1.5 miles of paved trails along the shoreline.
- **Lake Washington Bike Trail** is a mixed-use trail that can be accessed at the southern end of Gene Coulon Park in Reach G. The portion of the trail located to the north of the park is situated along Lake Washington Boulevard and provides views of the Lake until it is routed adjacent to I-405 near the City limits. (City of Bellevue Parks and Community Services 2003; King County GIS Center 2007).
- **Cedar River Boathouse** is located on pilings in the Lake at the north end of the Cedar River Trail (see Section 4.3.2.3 Public Access – Cedar River) in Reach I. The boathouse was Boeing's former hydrofoil development building until it was donated to the City. The City has leased the boathouse to Cascade Canoe & Kayak Centers since 2001. The Center offers canoe and kayak rentals, classes, and guided trips.
- The **Renton Municipal Airport Seaplane Dock** provides a parking area and informal public access adjacent to the seaplane dock in Reach J.

Opportunities for enhanced public access by reach include:

- **Reaches A and B** are single-family residential with one multi-family development and lie between the Bellevue city limits and the Seahawks Football Training Center. There is currently no public access in these reaches. There is a public trail along I-405, but it does not have views of the water. It is unlikely that new development will occur in this area, except possible redevelopment of the multi-family site, in which case public access would be required. Public agency actions to improve public access may include visual access from trail development along the railroad ROW inland of the residential lots; however, that may be limited by topography and vegetation. Opportunities for public access to the water include an existing undeveloped railroad right of way and potential public acquisition, including several parcels that do not currently have roadway access.
- **Reach C** includes the recently constructed Seattle Seahawks headquarters and training facility to the north and the Barbee Mill subdivision to the south. The Quendall Terminals parcel between is a Superfund site contaminated with coal tar and creosote. There is public access along a portion of the shoreline at the Seahawks site and to public aquatic lands at the Barbee Mill subdivision. Opportunities for provision of public access from development projects will occur after cleanup of the Superfund site which will provide for multi-use development and shoreline access across the entire property, consistent with vegetation conservation. Future redevelopment of both the Seahawks and Barbee Mill site is possible under the existing zoning which allows higher intensity use and provides an opportunity for continuous public access parallel to the shoreline along the entire reach as well as public access to non-single-family docks or piers. Public agency actions to improve public access may include access on public aquatic lands and a future trail along the railroad that likely will provide public visual access only in the northerly and

southerly portion of the reach because distances are too great and because views are, or will be, blocked by intervening buildings.

- **Reaches D and E** are primarily single family. There is one public access facility, the City of Renton Kennydale Beach Park. Public visual access is provided from Lake Washington Boulevard, which contains a bicycle/pedestrian path. It is unlikely that new development will occur in this area. Opportunities for future public access are likely primarily from public action on the shoreline. The most likely potential is for enhanced public views from Lake Washington Boulevard which is considerably above the elevation of the shoreline and provides views between structures and over the roofs of many structures. Enhancement of public views along Lake Washington Blvd. could be enhanced by providing viewing areas adjacent to travel and bicycle lanes with amenities such as benches. Potential views from a future trail along the railroad likely will be limited by the elevation and blockage in most areas by intervening buildings. Opportunities for public access to the water include public development of access on an existing undeveloped railroad right of way adjacent to the water and potential public acquisition of selected parcels, including portions of parcels to narrow to effectively develop.

- **Reaches F and G** encompasses Gene Coulon Park. There is a variety of public access at the park from trails, lawn areas, beach areas, boardwalks, and docks. There also may be opportunities for visual access from a future trail along the railroad and from Lake Washington Boulevard which is elevated above the park in some areas and could be enhanced by providing viewing areas adjacent to travel and bicycle lanes with amenities such as benches.

- **Reach H** contains the Southport mixed-use development that currently provides shoreline access along the entire shoreline, including a public walkway over the abandoned water discharge flume at the south edge of the property that connects with public aquatic lands. There may be additional opportunities for public access or water-oriented uses in future development phases including provisions such as seating and landscaping.

- **Reach I** contains the Renton Boeing Plant. Public access in this area includes the Cedar River Boathouse located on pilings in Lake Washington and accessed from the west from the Cedar River Trail. The boathouse includes a public fishing area and provides canoe and kayak rentals, classes, and guided trips. In the future, there may be opportunities for public access if the Boeing site is redeveloped. In the shorter term, there are opportunities for additional public access on public aquatic lands adjacent to about half of the shoreline of the Boeing Plant. These public aquatic lands, however, are currently classified for industrial use, although they are generally undeveloped. The City has developed a plan for a waterfront trail which would connect the public access at the Southport development to the Cedar River Trail and may be implemented in the future when environmental and security issues can be resolved.

- **Reach J** includes the Renton Airport. Public visual access to the shoreline is provided from a lawn area adjacent to the seaplane dock with the Will Rogers/Wiley Post monument. This park has access from Rainier Avenue and a parking area. The seaplane dock to the east of the park does not provide public access. If the Renton Boeing Plant were redeveloped to other uses in the future, changes in configuration or use of the municipal airport might be considered. If that occurred, public access along the shoreline and connection to the Cedar River Park may be considered. If the airport redeveloped to other uses, public access on the shoreline would be one element to be balanced with goals for ecological restoration and water oriented use. Public agency actions to improve public access in the shorter term should include enhancing opportunities for the public to approach the water's edge from the existing lawn area.

- **Reach** K is primarily single family with some multi-family and extends from the current City limits to the Seattle city limits. There is no public access in this area. Future redevelopment of a small mobile home park in the easterly portion of this reach and from redevelopment of existing multi-family uses provides the potential for future shoreline access balanced with goals for ecological enhancement. Public visual access is provided from Rainier Avenue. Potential for enhanced public views from Lake Washington Boulevard is likely only from public action that might include enhanced pedestrian facilities and acquisition of the several undeveloped parcels.

4.1.3.5 Infrastructure

A limited number of surface streets are located in the Lake's shoreline planning area. The major roadways that pass within the shoreline planning area are Lake Washington Boulevard, a two-lane collector arterial, and Rainier Avenue South, a four-lane principal arterial. The BNSF railroad tracks run along Lake Washington Boulevard. There are no bridges within the Lake's shoreline planning area. Nine stormwater outfalls that discharge into the Lake are recorded in the City's inventory (Map 9b), but it is likely that there are additional unrecorded outfalls from both the street system and private development. There is also a wastewater main located in the Lake that runs along a portion of Reach B and along the entire length of Reach D. The City GIS database does not include utility information for Reaches A and K (City of Renton 2008b; King County 2002).

4.1.3.6 Historic and Cultural Resources

The City's Comprehensive Plan (2004) addresses historic preservation. The Plan establishes a goal to maintain the City's natural and cultural history by documenting and appropriately recognizing its historic and/or archaeological sites.

Native American History

Lake Washington and the other shoreline areas within the City are part of the Duwamish Indian Tribe's historic fishing area. The entire Lake served as a cultural resource for the Tribe and other groups that harvested fish, game, and plant species in the area for generations.

The Duwamish Tribe is a Puget Salish-speaking group that resided in winter villages along the shores of the Cedar River, Black River, Duwamish River, Lake Washington, Lake Union, Salmon Bay, and Elliot Bay (Larsen Anthropological Archaeological Services [LAAS] 2005). The Tribe lived in cedar plank houses along the shorelines during the winter months. For the rest of the year, the Tribe would leave their winter houses to harvest salmon, dig clams, hunt wildlife, and gather plants. The dwellings constructed during the warmer time of year consisted of mats used as walls and planks taken from the winter village (Duwamish Tribe website 2008).

In 1855, the Tribe signed the Treaty of Point Elliott with the United States. The United States expected the Duwamish to leave their aboriginal territory and move to the Port Madison Reservation and, post-Treaty, the Muckleshoot Reservation. Some of the Duwamish moved, while others stayed and, later, sought federal recognition, which was denied by President George W. Bush's Administration in 2001. The Tribe is still seeking federal recognition in the U.S. Congress (Northwest Archaeological Associates (NWAA) 2007; LAAS 2003a).

The Muckleshoot Indian Tribe is a federally recognized Indian tribe that is the present-day political successor to tribes and bands that were party to two treaties with the United States in 1854 and 1855: the Treaty of Medicine Creek and the Treaty of Point Elliott. In those treaties, the party tribes reserved the right to fish at all usual and accustomed grounds and stations and to hunt on all open and unclaimed lands. These reserved treaty rights are the 'supreme law of the land' and where in conflict with state or local laws are preemptive. The Muckleshoot Tribe's right to exercise these reserved treaty rights today has been affirmed by federal court decisions and includes the right to harvest fish free of state interference, subject to conservation principles; to co-manage the fishery resource with the State; and to harvest up to 50 percent of the harvestable fish. (See United States v. Washington, 384 F. Supp.312,365 [WD Wn. 1974], aff'd 520 F. 2d 676 [9th Cir. 1975]; Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n, 443 U.S. 658 [1979].)

The Renton Shoreline Master Program study area falls within the recognized and court-affirmed usual and accustomed fishing grounds and stations of the Muckleshoot Tribe. The federally-recognized Snoqualmie Tribe has ancestral ties to the study area, but has no affirmed off-reservation treaty fishing rights. No other federally-recognized tribe may exercise treaty fishing rights within the study area without consent. The Muckleshoot Indian Tribe has a staff of fisheries biologists, operates two salmon hatcheries, and has taken an active role in managing salmon in the Cedar-Lake Washington and Lake Sammamish Basin. Due to the importance of the Tribe's fisheries resources, and other traditional resources, the Tribe continues to play an active role in the maintenance and protection of the City's shorelines (Muckleshoot Indian Tribe 2008).

Euro-American History

Euro-American settlement of the Renton area began in 1853. Settlement was driven by the discovery of coal at the nearby Squak Mountain. Timber harvesting and hop farming were also primary economic activities. Euro-American settlement continued to grow in the vicinity as transportation routes were developed.

During World War II, the Federal Government developed an aircraft manufacturing plant on former wetlands at the south end of Lake Washington, adjacent to the Cedar River. Aircraft production during the War brought thousands of people seeking employment to the region. The Boeing Airplane Company purchased this plant from the Government in 1946, at the conclusion of the war. Following the war, Renton remained a major manufacturing center for the Boeing Commercial Airplane Group, which produces the 737 Model at the South Lake Washington plant. Production at that plant continues today.

Other notable facilities in the area were built more recently, including the Seattle Seahawks headquarters and training facility on Lake Washington near Northeast 44th Street, and numerous small businesses and service industries (City of Renton website 2008a).

Registered and Inventoried Sites

The Washington State Department of Archaeology and Historic Preservation (DAHP) maintains a database system which catalogs sites that are registered with the Washington's Historic Register (WHR) and the National Register of Historic Places (NRHP). The database also has sites inventoried by state archaeologists and cultural survey reports prepared during project-specific planning efforts. A search of the database indicated the following:

- There are no state- or federally-registered sites within the shoreline planning area.
- There is one inventoried site. The U.S. Navy Martin PBM-5 Mariner (KI-404) is located in the Lake just off the seaplane ramp at the Boeing Plant. The flying boat

patrol bomber sank in 1949, while being ferried from the Naval Air Station in Seattle to the Boeing seaplane ramp in Renton. The aircraft remains where it came to rest in 1949, embedded in a dense silt bottom (Naval Historical Center 1997).

Potential for Encountering Archaeological Resources

Several cultural resources investigations have been conducted for recent projects in the City (LAAS 2003a; HRA 2005a; LAAS 2004). These reports note that areas along the Lake and the Cedar River have a high probability for encountering archaeological resources. There is also high probability along edges of contemporary river channels, old river channels, and streams within the Green River floodplain. Laura Murphy with the Muckleshoot Indian Tribe has indicated that the Tribe considers most of the City of Renton to have a high probability for archaeological resources. (Murphy 2009)

4.2 MAY CREEK

4.2.1 General Conditions

May Creek is an important salmonid stream and contains a substantial proportion of protected shoreline.

4.2.2 Hydrological and Biological Resources

The May Creek watershed is about 8,960 acres in Renton, Newcastle, and unincorporated King County and includes 26 miles of mapped streams, two small lakes, and over 400 acres of wetlands. Headwater streams come off steep, forested ravines from the north, east, and south. The basin can be divided roughly into two halves. The upper, eastern portion of the basin is characterized by less dense residential and agricultural development, and includes a significant portion of the undeveloped parkland on Cougar Mountain. Above May Canyon, the Creek lies in a formerly dredged, straightened channel at the center of a wide, very low-gradient valley. The lower, western portion of the basin is inside the UGA (primarily within the jurisdiction of the Cities of Renton and Newcastle) and is fairly dense urban residential development. About 50 percent of the basin is forested, but the amount of urban development is increasing (Kerwin 2001). The May Creek Basin Action plan was adopted in 2001 by King County and the Cities of Renton and Newcastle.

The portion of the Creek in Renton includes 2.3 stream miles of shoreline planning area partitioned into four reaches. The Creek is an important salmonid stream and contains a substantial amount of protected shoreline.

4.2.2.1 Tributaries and Associated Wetlands

Two small tributaries enter the Creek in Reach D (see Map 1b), both of which are ephemeral, non-salmonid bearing streams. One tributary enters on river left at the west end of Northeast 31st Street. Gypsey Creek drains south to enter May Creek at the upstream end of Reach D (see Map 3a). Kerwin (2000) identifies a passage barrier at the mouth of Gypsey Creek.

Much of the shoreline within 200 feet of the channel is riparian wetland in Reach C. The wetland is a mix of forested and scrub/shrub communities and extends north from the Creek along the eastern edge of the I-405 corridor. The Interstate and other roads substantially affect the hydrology of both the wetland and the stream. This wetland was likely part of a larger historic wetland complex that included the May Creek delta.

At least one additional wetland exists on river right, where the stream turns east. This wetland appears to lie on a slope and is likely sustained by seepage associated with confining Qgpc (glacial drift) geologic deposits. This wetland extends to within 200 feet of May Creek and may or may not be hydrologically-associated with the Creek. Other wetlands may occur in the area that have not yet been identified or mapped.

4.2.2.2 Fish and Wildlife Presence

Chinook, Coho, Sockeye, Winter Steelhead, and Cutthroat all use May Creek for spawning, rearing, and migration (Kerwin 2001; see Maps 5a and 5b). The portion of the stream located within the shoreline planning area provides limited spawning habitat, but all species migrate upstream past the ravine to spawn and rear in May Valley reaches.

One osprey nest is located on the Lake near the mouth of the Creek (see Map 5c). Riparian and backwater areas provide cover and foraging habitat for these birds and other species of birds and wildlife.

4.2.2.3 Instream and Riparian Habitat

Reach A, which measures 1,300 linear feet (0.25 miles) was substantially degraded in the past. The Creek was re-routed in the 1920s to accommodate industrial development and moved from its central location across the alluvial fan/delta to the east edge. The riparian area is in the process of revegetation as part of the adjacent Barbee Mill residential development to provide a corridor 35-feet-wide on each side. The narrow width of the buffer, the time required for vegetation to reach the size necessary to provide shade and temperature attenuation, and the presence of a trail with potential human disturbance limits riparian functions.

The May Creek delta was dredged in the past to provide log storage for Barbee Mill. Dredging is no longer needed for log storage and flood conveyance in May Creek for the recent subdivision was designed presuming reformation of the delta in the future (Renton 2003). Sediment from May Creek will reform a natural delta and provides natural, shallow water habitat as well as wetlands and eventually additional upland riparian habitat. It is likely to be ten to fifteen years before delta formation is readily apparent, but after filling in deeper areas dredged in the past, the area will fill rapidly thereafter and provide complex high quality aquatic and riparian habitat. As the delta expands, it is likely to provide an important habitat for Steelhead, cutthroat trout, and Chinook, coho, and sockeye salmon. The May Creek Basin Action Plan calls for enhancement of the delta if Barbee Mill operations should cease to provide a unique opportunity to establish an improved habitat area (Renton, King County 2001).

Reach B, measuring 1,150 linear feet (0.22 miles), is also located on the historic alluvial fan and like Reach A, the Creek is constrained by roads. The existing riparian corridor is intact, forested wetland, comprised primarily of small- to medium-sized deciduous trees.

Reaches C (measuring 3,200 linear feet [0.60 miles]) and D (measuring 6,270 linear feet [1.23 miles]) has riparian vegetation of sufficient width and density to provide a range of functions. Mixed and deciduous forest covers are the dominant cover types. In Reaches C and D, the Creek is constrained by residential development and Jones Avenue. However, some migration potential does exist, particularly in stretches of Reach D.

Pool habitat is present is Reaches B-D, but at low density and quality (providing limited ecological function). LWD is also present, but the small size of riparian trees limits recruitment potential. In addition, LWD present in the stream tends to be small and have a low influence on stream morphology unless accumulated in a jam. Jams or LWD accumulations that do form tend to be unstable and do not persist.

Residential lots are common in Reach D, and some forest has been converted to landscaping. Stream armoring for residential use is relatively minor. A landscaping business present at the upstream end of Reach D has also cleared a large portion of the shoreline, leaving a very narrow buffer.

Shoreline Modification

No quantitative data is available regarding streambank armoring and revetments and levees along May Creek, but a review of aerial photography suggests evidence of hydro-modifications in each of the following areas:

- **Reach A:** The stream is completely straightened with little naturalized riparian vegetation, the streambank, however is not armored.
- **Reach B:** Armoring associated with the grades of the Creek crossings of Lake Washington Boulevard and I-405. The stream section between the roads is relatively unaltered.
- **Reach C:** A portion of streambank in upper Reach C appears to be armored where it flows parallel to Jones Avenue (200 feet). Just upstream, all or a portion of 500 feet of the right streambank appears to be hydromodified to protection a private residence.
- **Reach D:** Some modification is associated with five private residences and four road crossings on the north side of the Creek near the end of the reach. A vegetated buffer is present between the residences and the Creek.

4.2.2.4 Floodplain and Channel Migration

The May Creek floodplain has been delineated in Federal Emergency Management Agency (FEMA) studies and maps (FEMA 2007). Floodplains are indicated on Map 4d. The floodplain below Lake Washington Blvd. was extensively modeled as part of the Barbeee Mill subdivision and the channel and riparian area designed to contain the 100 year flood presuming the re-establishment of the delta.(Renton 2003). Between Lake Washington Blvd. and I-405, the floodplain is up to 300 feet wide with the more extensive potion to the north of the channel.

East of I-405, the floodplain varies from about 50 feet to up to 200 feet with the more extensive area in the vicinity of NE 40th Street and between NE 36th Street and NE 32nd Street. Portions of the stream were channelized and relocated as part of I-405 construction in the 1960s. There are no flood control facilities on May Creek. Review of aerial photos taken since the 1930s indicate relatively little change in the channel location. A preliminary assessment of the Channel Migration Zone (CMZ) by Department of Ecology staff of the area east of I-405 indicates that the creek is located within a gorge that partially confines the stream providing topographic control on stream location. Immediately east of I-405 the stream flows through public land except for a few private lots between N 36th and N 37th Street and at about N 32nd Street. The stream is contained by topography on both sides and is bounded by I-405 on the west, and by either Jones Road or private residences on the buff above the creek on the east side. The stream has an east-west orientation just south of 31st Street and is bounded by a very high gorge on the south side. It crosses north of NE 31st street at about the 2000 block and crosses back south at about the 2200 blockwithin a level area at the confluence with Gypsy Creek. This area was extensively farmed in the 1930s but is now large lot residential development largely on the north side of the creek but with one residence at 2415 NE 31st Street reached by a bridge. West of Edmonds Avenue NE the stream is contained in a deep wooded gorge. Most of the stream corridor south of NE 31st Street is in public ownership as part of the May Creek Park.

The channel migration area was likely the entire valley bottom before extensive human alteration. The steep slopes bound the channel migration area on the east and south and Jones Ave NE/NE 31st Street and residential development provide a boundary on the east and north, in addition to topographic constraints. Ecology has provided a rough estimate of channel migration rate of 2 to 6 feet per year and results in the estimated 10year channel migration area shown in Figure 13a which indicates a high channel migration hazard. This zone generally exceeds the 500 year floodplain as mapped by FEMA except in the vicinity of the confluence of Gypsy Creek. Except at this flatter location, the CMZ is contained by natural topography. The entire CMZ and FEMA mapped floodplain is within Shoreline Management Act jurisdiction as being within 200 feet of the OHWM and the floodway.

The Shoreline Guidelines in WAC 173-26-221(3)(b) direct local governments to take into account the river's characteristics and its surroundings, noting that in some cases, river channels are prevented from normal or historic migration by human-made structures or other shoreline modifications. Legally existing artificial channel constraints that limit channel movement and therefore are not to be considered within the channel migration zone of May Creek Reaches C and D include the existing Jones Road and SE 31st Street as well as the legally established shoreline stabilization structures for a few single family residences.

For the most part, the CMZ for May Creek is within publicly owned open space. For single family residences, future redevelopment may allow for establishment of a vegetation conservation buffer area that allows additional area for channel migration. In addition, both King County and the City of Renton have a longstanding policy of acquiring land in the May Creek Valley on a willing-seller basis as funds become available. This may lead to additional public ownership in the area and opportunities to remove human-made constraints.

4.2.2.5 Other Natural Features

The May Creek floodplain is confined, but coarse alluvial deposits support a high degree of function. In addition to historic and existing riparian wetlands, the floodplain presents some property hazard due to flooding and potential for liquefaction or other mass wasting during an earthquake (see Maps 4a and 4c). These deposits also support a shallow aquifer and sustained aquifer recharge areas in the shoreline valley and upland areas in Reach D (see Map 4c). The aquifer recharge area extends from the shoreline across the entirety of the upstream watershed.

Steep slopes present landslide and erosional hazards on the river left of Reach D where the Creek turns east. The valley is confined by steep walls in Reaches C and D that also present landslide and erosional hazards. However, those areas are generally located outside of the shoreline planning area (see Map 4a).

4.2.3 Built Environment

4.2.3.1 Existing and Planned Land Use

Existing Land Use

Land-use patterns along the shoreline of May Creek are a mix of parks, recreation and open space, undeveloped lands, and residential. Land-use within the Creek's shoreline planning area was assessed using 2008 King County Assessor's parcel data.

- **Reach A:** The portion of this Reach categorized as undeveloped (29 percent) by the King County Assessor is undergoing residential development as part of the redevelopment of the Barbee Mill sawmill. Therefore, the future amount of undeveloped land will drop to zero percent. Residential land-use will increase from four to 58 percent. The remaining shoreline planning area is dedicated to roadways and railroad tracks (32 percent).

- **Reach B:** This Reach is a mix of undeveloped (38 percent), low density residential (28 percent), roadways (22 percent), and commercial land-uses (12 percent).
- **Reaches C and D:** These reaches are primarily made up of the May Creek Greenway and May Creek Park (designated as vacant by King County Assessor). Reach C is also dominated by roadways (56 percent).

Planned Land-Use

The City's zoning and Comprehensive Plan land-use designations are Commercial/Office/Residential in Reach A (categorized as mixed-use to coincide with King County Assessor land-use classification) and Residential Low Density and Resource Conservation in Reaches B through D (City of Renton 2008b).

Figure 4-7 shows the proportions of current land-use, zoning and Comprehensive Plan land-use designations for each May Creek shoreline reach. The mixed-use category encompasses the Commercial/Office/Residential designation in a more general category for consistency with King County Assessors land-use coding.

The data for City zoning and Comprehensive Plan land-use exclude roadways and railroad tracks. Roads and railroads classified as transportation are included in the existing land-use data.

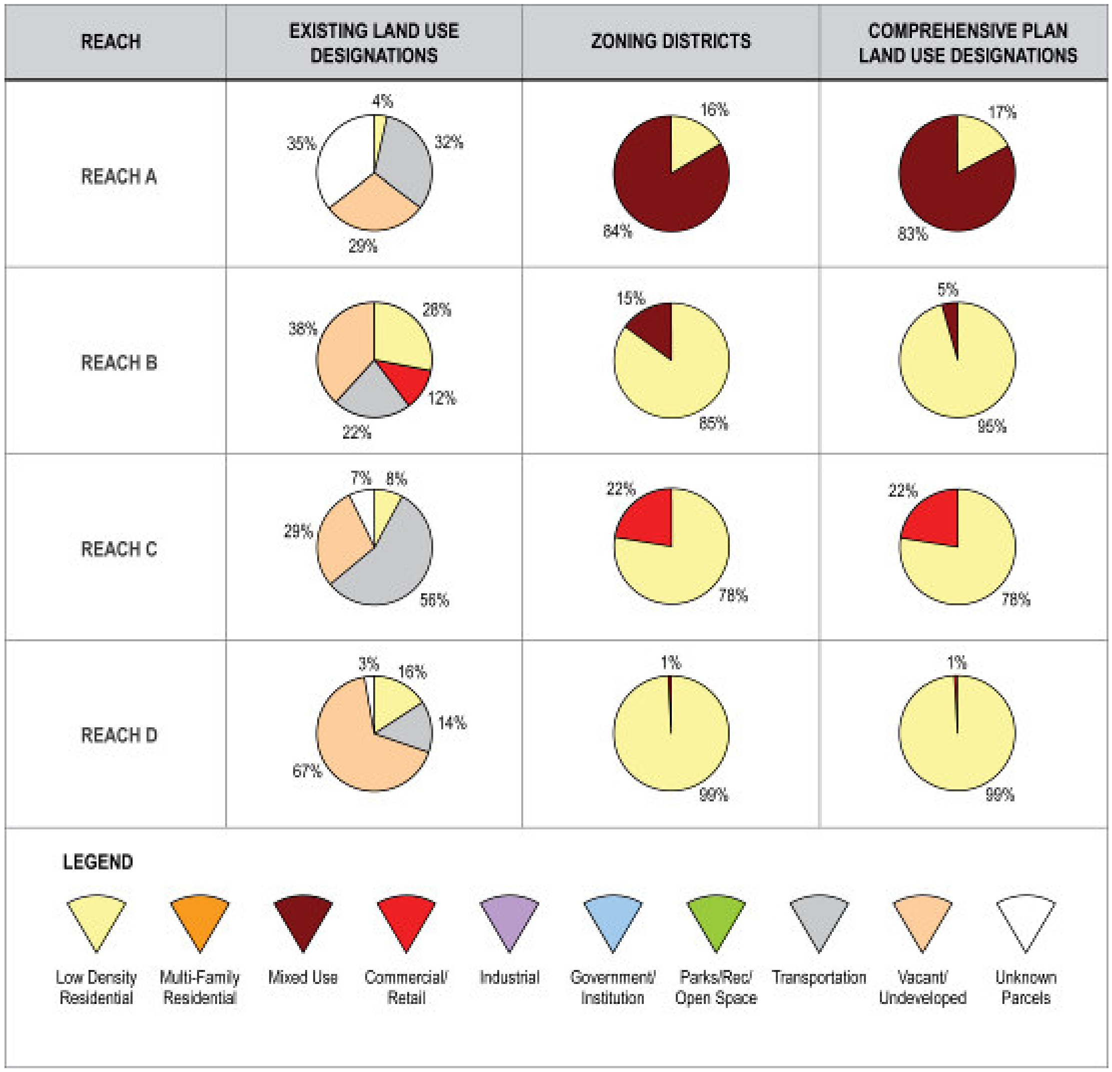

Figure 4-7 Percentages of Existing, Allowed and Planned Land Use by Reach in the May Creek Shoreline Planning Area

The May Creek shoreline does not currently have any water-dependent or water-related uses. A review of King County Assessor's data revealed that there is only one property classified as commercial along the Creek's shoreline. The commercial property is an office building, which would not be considered a water-dependent or related use. The May Creek Greenway and May Creek Park described in Section 4.2.2.3 (Public Access – May Creek) could potentially provide water-enjoyment uses if public access to the shoreline is established.

<u>Undeveloped or Vacant Lands</u>

Table 4-6 provides the percentage of undeveloped parcels and undeveloped area by reach. As described earlier, the Port Quendall parcels designated as undeveloped will be developed with residential units. Undeveloped areas in Reach B are designated for single-family and mixed-use development. A large portion of undeveloped area in Reaches C and D is part of the May Creek Greenway and May Creek Park.

Table 4-6. Existing Development of Waterfront Parcels along May Creek

Reach	# of Lots	% Undeveloped Parcels	% Undeveloped Area
MC-A	82	76%	29%
MC-B	4	50%	38%
MC-C	20	60%	29%
MC-D	30	57%	67%

Source: King County, 2008; City of Renton, 2008a

4.2.3.2 Impervious Areas

Impervious areas were analyzed for the May Creek shoreline planning area based on the City's GIS data. Table 4-7 shows the total impervious area and percent of impervious area for May Creek. The data only includes impervious surfaces provided by buildings and public ROWs. However, most impervious area within May Creek's shoreline planning area is roadway. Roadway pavement occupies an especially large portion of Reach C, since I-405 travels along the Reach's entire length.

Table 4-7. Impervious Surface in May Creek Shoreline Planning Area

Reach	Total Acres	Impervious Area (Acres)	Percent Impervious	Roadway % of Total Impervious areas	Building % of Total Impervious Areas
A	15	3	22%	86%	14%
B	12	3	23%	98%	2%
C	18	10	57%	98%	2%
D	46	7	15%	95%	5%

Source: City of Renton GIS data 2005

4.2.3.3 Public Access

The following parks are located in the May Creek shoreline planning area. The parks do not provide access to the shoreline (City of Renton Parks and Recreation website 2008):

- **Barbee Mill Trail:** A pedestrian trail is provided on the east side of the Creek within the 35-foot-wide riparian corridor provided in the residential redevelopment of the Barbee Mill site.
- **May Creek Greenway:** A 30-acre natural area is located on the south bank of May Creek in Reaches C and D. Ownership of the greenway is split between the City and County.
- **May Creek Park:** A City-owned park with ten acres of natural area is located in Reach D.

Opportunities for enhanced public access along May Creek include:

- The public access trail from near the mouth to Lake Washington Boulevard, and from near I-405 to the east.
- The private property between Lake Washington Boulevard and I-405 may be required to provide public access at the time it develops, although public access through the culverts under I-405 are likely to be very problematic.

- Access across the freeway may be diverted to 44th Street, or a separate pedestrian overpass could be considered.
- Much of the stream corridor east of I-405 is publicly-owned. Public access improvements here are most likely to take the form of interpretive trails and will require careful location and design to avoid degradation of ecological functions.

4.2.3.4 Infrastructure

There are three bridges that cross May Creek. Lake Washington Boulevard and the BNSF railroad tracks cross May Creek between Reaches A and B. I-405 crosses May Creek between reaches B and C. I-405 also travels along the entire length of Reach MC-C. Two stormwater outfalls have been recorded along May Creek in the City's inventory (Map 9b). It is likely that there are additional unrecorded outfalls from both the street system and adjacent development (City of Renton 2008b; King County 2002).

4.2.3.5 Historic and Cultural Resources

Native American and Euro-American historic use of the area is detailed in Section 4.1.4.5

A search of the DAHP database for resources within the May Creek shoreline indicated the following:

- There are no state- or federally-registered sites within the May Creek shoreline planning area.
- There are no inventoried sites within the May Creek shoreline planning area.
- There are two ethnographic sites located within the shoreline planning area. A large Duwamish village site was reported to have been located near the mouth of May Creek. The village was reported to have included two longhouses. A portion of a trail used by Native Americans for resource procurement and trade has been identified along the northern bank of the Creek. The trail may have been part of a series of interconnected trails that provided access to eastern Washington (Western Shore Heritage Services, Inc., 2005).

As with Lake Washington, May Creek falls within the recognized usual and accustomed fishing grounds and stations of the Muckleshoot Tribe.

4.3 CEDAR RIVER

4.3.1 General Conditions

The upper watershed of the Cedar River is characterized by second and old-growth forest, while the lower watershed has been extensively altered. After its re-routing to the lower end of Lake Washington in 1916, the Cedar River has been channelized and significantly impacted by high population growth and development. Along lower reaches of the river, this has included hard armoring (bulkheads), scouring, construction of docks and piers, and removal of native vegetation.

4.3.2 Hydrological and Biological Resources

4.3.2.1 Tributaries and Associated Wetlands

Historically, the Cedar River flowed into the Black River then drained into the Green/Duwamish River that flows into Elliott Bay in the Puget Sound. In 1912, the lower 1.5 miles of the Cedar River were redirected into a constructed channel and diverted to flow into Lake Washington. This was done because of flooding and the anticipated lowering of the Lake as part of the Ballard Locks being constructed at the time by the USACE.

The lower 1.25 miles of the River has been periodically dredged to a depth of 10 feet since 1912 to protect against flooding. The dredging addresses sediment deposition in the constructed reach caused by low gradient and sediment transport from the upstream watershed. Commercial Waterway District No. 2 was formed to implement the channel modifications and dredging of the river and delta. The Commercial Waterway District performed maintenance dredging of the Lower Cedar River approximately every ten years until it dissolved in 1957. Since it was a special purpose District within the City's corporate boundaries, the City assumed the District's ownership of the constructed channel and the responsibility for maintaining the constructed channel.

During this period, the City dredged the channel to a maximum depth of 10 feet to maintain channel capacity and decrease flooding from the mouth to Logan Avenue Bridge. The City continued dredging the channel and delta but with a large reduction of dredging quantities in the 1970s until 1983, when dredging was discontinued. From 1983 to 1998, the channel was not maintained to the original depth due to various factors, including restricted access to the channel after the north. Boeing North and South bridges were built across the river and difficulties in obtaining necessary permits. Stoneway Gravel mined the channel upstream of I-405 for gravel until the early 1970s, removing 10,000 to 50,000 cubic yards of material annually.

Due to the discontinuation of dredging on the lower 1.25 miles of the River, channel capacity was gradually reduced. During a November 1990 flood, the river overflowed its banks and flooded the Renton Municipal Airport, Boeing facilities and adjacent properties, resulting in significant damages. Following the flood, the City worked with the USACE to address the problem.

Using hydrologic modeling, it was predicted that through a process called aggredation, sediment loads would be transported downstream from the highlands and fill-in the lower Cedar River channel bed in less than 20 years. During storm events, the River could overflow the aggredated channel, run onto the Renton Municipal Airport's runways and other impervious surfaces, and flow into the center of downtown Renton. This flooding would clearly cause a public safety hazard, and result in significant property damages.

To eliminate this threat, the City and USACE created the Section 205 Flood Hazard Reduction Project (Cedar River 205 Project). In the summer of 1999, Phase I of the project commenced: the lower 1.25 miles of the River channel were dredged at an average depth of four feet from the Williams Avenue Bridge to the Lake, slightly downstream of the North Boeing Bridge Phase II of the project. Phase II was undertaken in late 1999 and 2000, and included the construction of levees and floodwalls along the lower 1.25 miles of the River.

Ongoing maintenance in the form of periodic dredging, is predicted to be necessary every three years in perpetuity to maintain the design level of protection against the 100-year recurrence interval event with at least 90 percent of reliability. However, subsequent dredging of the channel has not been necessary, from the combined result of operational changes in storage and flow releases by the City of Seattle at the Chester Morse Masonry Dam and lower than average precipitation from 2000 to 2005.

The City continues to monitor annual sedimentation along the lower River to ensure that a bed elevation that would necessitate maintenance dredging has not been reached. Future maintenance dredging is required by the City's agreement with the USACE for Cedar River 205 Project in order to maintain the flood protection benefits of the federally-constructed project. The City is also required to maintain a levee certification and keep floodplain mapping current. It is estimated that maintenance dredging of the lower 1.25 miles of the River will be necessary within the next four to seven years, depending upon the flood events and the rate of sediment deposition.

Prior to 1957, the Commercial Waterway District No. 2 may have done some dredging of the Cedar River Delta for navigational purposes. The delta may also have been dredged for gravel mining purposes. More recently, the delta was dredged by the City in 1993 to reduce a bird-strike hazard to airplanes using the Renton Municipal Airport. The permitted dredge depth was four feet below the wintertime water level of Lake Washington. The Airport is currently planning limited dredging of the delta to maintain access to the seaplane base dock. There are no future plans to dredge the delta for flood control purposes since it was determined that the River elevation upstream of the North Boeing Bridge on flood elevations (Straka 2009).

Future dredging could be proposed for navigational purposes or boater safety.

Six tributaries drain to the Cedar River (Table 4-8), all of which are located in Reaches C and D. These tributaries flow across the historic Cedar River floodplain before reaching the valley wall. Two small wetlands are located on the left bank of Reach C, slightly downstream of Maplewood Creek. Also, a large associated wetland spans Reach D and is contained mostly in the open space of Maplewood Golf Course and Ron Regis Park (see Map 3a).

4.3.2.2 Fish and Wildlife Presence

Cedar River supports a Chinook stock that is listed as Threatened under the ESA (Kerwin 2001; see Maps 5a and 5b). Fall Chinook produced in the River have a broad range of life histories. Rearing can be stream-type or a combination of stream- and lake-type. Young Chinook commonly rear for some time in the very shallow portions of the River with low current velocities. These areas tend to be relatively free of the sculpins that are prevalent predators in deeper water and along riprap shorelines. Chinook juveniles then migrate into Lake Washington from late winter through early summer (February-July), where they continue to rear or move directly to saltwater.

Coho are produced in the River, but in recent years only in small numbers (Kiyohara and Volkhard, 2007). Coho generally spend their first year of life rearing in freshwater prior to migrating to the ocean as smolts in their second year of life. Juvenile Coho commonly rear along streambanks and in off-channel habitat. Pollok et al. (2004) found that young Coho prefer beaver ponds in the Stillaguamish River and they likely prefer similar habitat in the Cedar and Green Rivers. Coho smolts migrate through the lower Cedar River in late April through May on their way to the ocean.

Cedar River Sockeye appear to be derived from the Baker Lake/Skagit River stock (Hendry et al. 1996) planted in Lake Washington in the 1930s and 1940s. The Sockeye stock is depressed (SASSI 1984) but not ESA-listed. Numerous Sockeye spawn in the River. Young Sockeye may rear in the River for some time prior to migrating to the Lake for additional rearing. In the River, the young Sockeye may seek off-channel ponds for winter rearing (Hall 2002)

Steelhead also reproduce in the Cedar River. Commonly, the young Steelhead rear within the river and its tributaries for two or more years before beginning their migration to the ocean through Lake Washington. During their riverine rearing, young Steelhead are substantial predators of migrating Steelhead salmon (Beauchamp 1995). At an age of two years or more, the juvenile Steelhead migrants tend to be substantially larger than other salmon migrants.

Cutthroat trout also occur in Cedar River. Cutthroat prefer steep riffle habitat, but use an entire river for rearing and migration. Preferable spawning habitat is not common within the shoreline located in the City.

Bull trout spawn in the upper Cedar River and rear in Chester Morse Lake. Small numbers of sub-adult and adult Bull trout have been observed in Lake Washington over a number of years. These Bull trout appear to be migrants into Lake Washington from other river basins or fish that have passed downstream from Chester Morse Dam and become isolated from their population.

Essentially, the lower portion of the Cedar River within the City functions as a rearing/migratory corridor for most of the anadromous salmon and trout produced in the watershed.

Before being rerouted in 1916, the Cedar River drained into the Duwamish River via the Black River. Pink and Chum salmon may have utilized the Cedar River at that time; however, they no longer occur.

Other native fish species found in the River may include western brook lamprey, river lamprey, peamouth chub, largescale sucker, pygmy whitefish, northern pikeminnow, speckled dace, char, and five species of sculpin. Numerous species of nonnative fish also occur in the watershed including yellow perch, brown bullhead, black crappie, pumpkinseed sunfish, and largemouth and smallmouth bass, which can be significant predators of juvenile salmonids (Kerwin 2001; Parametrix 2000). Many of these species are found in the Green River. Although many may occur in shallow shoreline areas, none are known to require specific shoreline habitat characteristics. Altered shoreline areas, however, such as the rock-lined levee areas along the Cedar River that lack wood, may provide preferred habitat for salmonid predators (e.g., sculpin and bass).

Table 4-8. Cedar River Shoreline Tributary Characteristics

Reach	Stream	Location	Stream Rating[a]	Known Salmonid Use	Passage Barriers
C	Ginger Creek	Left bank	3	Cutthroat[b]	None
	Unnamed Tributary	Left bank	4	None	None
	Maplewood Creek	Right bank	2	Coho, Cutthroat	Full
	Molasses Creek	Left bank	2	Coho, Sockeye, Cutthroat	Partial
D	Madsen Creek	Left bank	2	Coho, Sockeye, Steelhead, Cutthroat	None
	Unnamed Tributary	Right bank	3	Cutthroat	None

[a] 2= Perennial salmonid-bearing; 3 = Perennial non-salmonid bearing; 4 = ephemeral non-salmonid bearing. Source: Jones and Stokes (2005).

[b] SSHIAP data do not report the presence of cutthroat.

4.3.2.3 Instream and Riparian Habitat

Reaches A and B are entirely artificial, created as part of watershed realignment early in the 20th Century, and are completely constrained between levees and revetments. These reaches were regularly dredged to prevent flooding from their completion in 1912 until the mid–1970s. Portions of the reaches were again dredged in 1999 for the first time since the mid-1970s. Instream habitat in these reaches is almost entirely riffle, with little habitat complexity. Land-uses prevent floodplain connectivity and have eliminated the potential for re-connection with a natural floodplain or the establishment of a riparian corridor. Channelization and existing land-uses also prevent significant LWD from accumulating in the channel. Reaches A and B are also very low-gradient and depositional, and the substrates have high levels of fine sediments.

As a result of existing land-use, Reaches C and D have a higher degree of function than downstream reaches. Both Reaches C and D are partially diked and leveed, although Reach D is less constrained, allowing for the development of gravel bars and a very small degree of meandering and channel migration. At present, Reach D has a significant amount of LWD due to the landslide caused by the Nisqually Earthquake in 2001. This includes log-jams behind the Ron Regis Park, just upstream of the Elliott Spawning Channel. Most of the left bank of Reach C is deciduous forest, and the portion of Reach D adjacent to the golf course and Ron Regis Park is deciduous forest. These forested areas are generally at least 200 feet in width. Upstream of the Park, residential development has encroached onto the shoreline, and forested riparian cover is very limited.

Despite the presence of some functional riparian forest in Reaches C and D, LWD recruitment potential is very low, both because channelization limits the River's ability to migrate and accumulate wood, and because existing trees, if recruited, would not have a significant impact on stream morphology.

Reach D has accumulated individual pieces of LWD, but it has not accumulated in jams. These pieces may provide some instream cover for fish, but their impact on river habitat complexity is negligible. Instream habitat in Reaches C and D is almost exclusively riffles and glides.

In Reach C: existing land-use including a former sand and gravel operation and a large multi-family complex have substantially altered the shoreline environment through elimination of most native vegetation and shoreline armoring. This alteration has removed most aquatic habitat value from these sections of the shoreline and contribute to cumulative impacts of alteration of the stream environment that contributes to continuing trends in the decline in ecological functions including interruption of infiltration, and shading s necessary to maintain the temperatures, providing organic inputs critical for aquatic life including food in the form of various insects and other benthic macroinvertebrates, filtering and vegetative uptake of nutrients and pollutants from groundwater and surface runoff, regulating of microclimate in the stream-riparian corridors and other functions. Single family development in the reach contributes to cumulative trends of degradation and varies depending on the intensity of development, building setbacks and the extent of alteration of vegetation and bulkheading.

In 1995, the County constructed a groundwater-spawning channel adjacent to the River behind the Maplewoood Golf Course on City's property at approximately RM 4.4. The County groundwater-spawning channel was constructed as part of the King County Elliott Levee Reconstruction and Habitat Enhancement Project to provide spawning habitat for Sockeye salmon (Straka 2008). In 1998, a groundwater-fed spawning channel was constructed adjacent to Ron Regis Park at approximately RM 4.8. The Elliott Spawning and Rearing Habitat Channel was constructed in 2000, behind the Maplewood Golf Course at approximately RM 4.6. Both of these projects were provided as mitigation for dredging of the Cedar River in Reach A. (USACE 1997a & 1997b).

In 2001, the Nisqually Earthquake caused a landslide that blocked the Cedar River, which resulted in the Cedar River diverting into the groundwater-spawning channel. The City requested assistance from the USACE to replace the groundwater-spawning channel. The replacement channel is proposed for construction on the left bank of the River at approximately RM 3.4. Land rights in the area have been acquired, and design and permitting have been completed; however, construction of the project has been postponed indefinitely due to lack of federal funding (Straka 2008).

4.3.2.4 Floodplain and Channel Migration

The Cedar River floodplain has been delineated in Federal Emergency Management Agency (FEMA) maps and additional studies done for the city by the Corps of Engineers and Tudor Engineers in the late-1970s and by Northwest Hydraulics Consultants in 2002. The results of that floodplain delineation are shown in Map 4e.

Reaches A and B east of I-405 is a constructed and managed channel. The City of Renton has a floodplain management program that includes maintenance of the channel which was created in 1912 by Commercial Waterway District No. 2 and assumed by the city in 1957. The City dredged the channel and delta periodically until 1983 when dredging was discontinued. During a November 1990 flood, the river overflowed its banks and flooded the Renton Municipal Airport, Boeing facilities and adjacent properties, resulting in significant damages. Following the flood, the City and the US Army Corps of Engineers (USACE) developed an analysis of flooding potential that predicted that aggredation due to sediment loads transported down the river would fill-in the lower Cedar River channel bed in less than 20 years. During storm events, the River could overflow the created channel, run onto the Renton Municipal Airport's runways and other impervious surfaces, and flow into the center of downtown Renton. This flooding would clearly cause a public safety hazard, and result in significant property damages. It would also negatively-impact salmonid migration upstream and spawning.

To eliminate this threat, the City and USACE created a Section 205 Flood Hazard Reduction Project (Cedar River 205 Project). In the summer of 1999, Phase I was implemented including dredging the lower 1.25 miles of the channel an average depth of four feet from the Williams Avenue Bridge to downstream of the North Boeing Bridge. Phase II of the project undertaken in late 1999 and 2000 included the construction of levees and floodwalls along the lower 1.25 miles of the River.

Ongoing maintenance, in the form of periodic dredging, is predicted to be necessary in perpetuity to maintain the design level of protection against the 100-year recurrence interval event with at least 90 percent of reliability. However, subsequent dredging of the channel has not been necessary, from the combined result of operational changes in storage and flow releases by the City of Seattle at the Chester Morse Masonry Dam and lower than average precipitation from 2000 to 2005.

The City continues to monitor annual sedimentation along the lower River to ensure that a bed elevation that would necessitate maintenance dredging has not been reached. Future maintenance dredging is required by the City's agreement with the USACE for Cedar River 205 Project in order to maintain the flood protection benefits of the federally-constructed project. The City is also required to maintain a levee certification and keep floodplain mapping current. It is estimated that maintenance dredging of the lower 1.25 miles of the River will be necessary within the next four to seven years, depending upon the flood events and the rate of sediment deposition.

In Reach C between I-5 and SR 169 the floodplain is up to 400 feet wide in the vicinity of the former Stoneway Concrete plant immediately east of RiverView Park. It is approximately 1,200 feet wide west of SR 169 and extends over about half of the subdivision in that area. The Maplewood residential neighborhood on the north side (right bank) immediately downstream of SR 169 is subject to a number of flood-related hazards. According to flood studies more than half the neighborhood would be inundated by shallow flooding in a 100-

year event. In addition, an active landslide scarp is located directly across the river from the neighborhood. The Person Flood Control Revetment was built on the left bank to stabilize the base of the landslide-prone slope, but it ultimately provides minimal protection against a landslide feature of such large scale. The occurrence of a major landslide here triggered by heavy rains, a earthquake, or just normal forces acting over time could block all or a portion of the channel, and could potentially redirect the flow of the river into the residential area. The King County flood management plan proposes voluntary buy-out of this area since there is no reliable means to reduce long term landslide hazard. (KCFCZD 2007)

In Reach D east of SR 169 the floodplain is 1,200 to 1,500 feet wide and extends in many areas from SR 169 to the edge of steep bluffs on the north side of the river. Uses within this area are largely public open space, including the Maplewood Golf Course and Ron Regis Park as well as some single family residences immediately east of the city limits within the Urban Growth Area (UGA).

A channel migration zone (CMZ) study by King County is currently underway. A preliminary assessment was made by the Department of Ecology staff.

In this reach the channel on the left bank (north side) is generally confined by steep slopes except for the area within about a quarter mile upstream of SR 169, which includes the Maplewood Golf Course, and about a quarter mile downstream of the 154th Avenue bridge, which contains about 20 residential lots ranging from one half to seven acres in size. The steep slopes of the left bank influence channel migration through periodic landslides. A recent slope failure during the Nisqually earthquake shifted the channel to the right (south).

The historic channel migration area likely included the entire river bottom before extensive human alteration including construction of SR 169 and the former Milwaukee Road railroad right of way (now the Cedar River trail). Aerial photos dating back to the 1930s indicate that the areas occupied by channels since that time period are within the floodway as mapped by FEMA. The probable CZM extends nearly the width of the floodplain. About one quarter to half of the floodplain in this area is in SMA jurisdiction: 200 feet from the floodway.

Ecology has employed a simplified method to determine possible migration areas through calculating an annual migration rate based on recent channel migration. These annual rates can be used are then used to calculate the distance the channel could travel over a specified period of time. Ecology staff have estimated the annual migration rates for this reach at between 8 and 27 ft per year. Figure 13b shows a 10 year high hazard area. (Olson 2009)

For the most part, the CMZ for May Creek is within publicly owned open space including the Maplewood Golf Course and Ron Regis Park. There also are about 20 single family residences between Ron Regis Park and the 154th Avenue SE bridge.

The Shoreline Guidelines in WAC 173-26-221(3)(b) direct local governments to take into account the river's characteristics and its surroundings, noting that in some cases, river channels are prevented from normal or historic migration by human-made structures or other shoreline modifications. Legally existing artificial channel constraints that limit channel movement and therefore are not to be considered within the channel migration zone. At the outermost limit, SR 169 provides an outside limit to the potential CZM. There are, however, a number of existing levees in this reach of the Cedar River owned and maintained by the King County Flood Control Zone District and shown in the inset in Figure 13b. These levees and revetments are part of a system located along many of the meander bends along the lower and middle portions of the river. Most of these were built in the 1960s and 70s to prevent lateral migration of the river that might cause flood or erosion damage to developed properties and infrastructure. They are designed to direct the river's flow rather than to contain flood flow. These levees effectively contain the CMZ to within close proximity of the existing channel. The King County 2006 Flood Management Plan provides a policy direction to selectively set-back flood protection facilities to reconnect the river with its floodplain and allow habitat restoration work to take place while managing flood hazards to protect private property and infrastructure. (King County 2006)

4.3.2.5 Other Natural Features

Despite dikes and levees along the extent of the shoreline, Reaches A and D are still at significant risk of flooding. Affected areas include Renton Municipal Airport, Maplewood Golf Course, Ron Regis Park, and residential areas upstream of the Park. With the exception of a small area in Reach C, the entire shoreline is also an aquifer recharge zone (see Map 4c).

The valley walls bordering the Cedar River floodplain in Reaches C and D have a high potential for surface erosion and moderate risk of landslides (see Map 4a). Two short sections of shoreline on the left bank of Reach C and two sections on the right bank of Reach D have a very high landslide risk. In addition, the portion of shoreline surrounding Ginger Creek (Reach C) is a coal mine hazard area on both banks. The entire floodplain of the River is an earthquake hazard area (see Map 4a).

4.3.3 Built Environment

4.3.3.1 Existing and Planned Land-Use

Existing Land-Use

Land-use patterns along the shoreline of River are a mix of residential, parks, recreation and open space, government/institutional and undeveloped lands. Transportation dominates land-uses in the shoreline planning area (27 percent). Existing land-use within the River shoreline planning area was assessed using 2008 King County Assessor's parcel data.

- **Reach A:** The west bank upstream of the mouth of the river is currently in use by the Renton Municipal Airport (classified as government/institutional in the Assessor's classification [43 percent]). The east bank is devoted to the Cedar River Park. The Assessor's use-classification of the balance of the shoreline planning area is as roadways (35 percent); parks, recreation and open space (15 percent); and industrial (six percent). Most of the Boeing Plant east of the river is outside the 200-foot shoreline jurisdiction.
- **Reach B:** The majority of Reach B is in use by roadways and railroads (53 percent). The remaining uses include government/institutional (16 percent); single-family residential (nine percent); multi-family residential (seven percent); commercial/retail (six percent); and parks, recreation and open space (four percent). Government/institutional uses include the Renton Senior Center, Renton Library, a religious institution, a non-profit organization and the Renton Parks Department maintenance site.
- **Reach C:** Existing land-use includes low density residential (18 percent); parks, recreation and open space (seven percent); multi-family residential (four percent); and industrial (four percent). Undeveloped lands (38 percent) and roadways and railroads (25 percent) dominate the existing land-use. A large amount of land classified as undeveloped lands is the Cedar River Greenway System (see: Section 4.3.2.3, Public Access).

- **Reach D:** The dominant land-use is parks, recreation and open space (31 percent), followed by undeveloped lands (24 percent), low density residential (21 percent), and roadways (15 percent).

Planned Land-Use

The City's zoning and Comprehensive Plan land-use designations are essentially the same within the Cedar River shoreline planning area. Reach A is zoned Industrial (89 percent) and Mixed-Use (11 percent), and is categorized as Urban Center-North in the Comprehensive Plan, allowing a range of uses. Reach B is zoned as Mixed-Use (22 percent), Low Density Residential (39 percent), and Multi-Family Residential (24 percent) and Commercial (15 percent) and is categorized as Urban Center-Downtown land-use and Center Downtown in the Comprehensive Plan. Reach C is zoned Low Density Residential (85 percent) and Mixed-Use (15 percent) and categorized as Commercial/Office/Residential and Residential Low Density in the Comprehensive Plan. Reach D is zoned as Low Density Residential and categorized as Residential Low Density, R-4 and Resource Conservation/R-4 in the Comprehensive Plan (City of Renton 2008b). The percentages indicated are based on the King County Assessor's coding system.

Figure 4-8 shows the proportions of current land-use, zoning and Comprehensive Plan land-use designations for each Cedar River shoreline reach. The data for City zoning and Comprehensive Plan land-use excludes roadways and railroads, which are categorized as transportation, are included in the existing land-use data. The mixed-use category encompasses the Urban Center, Downtown, Center, Downtown and Commercial/Office/ Residential designation for consistency with King the County Assessors land-use coding.

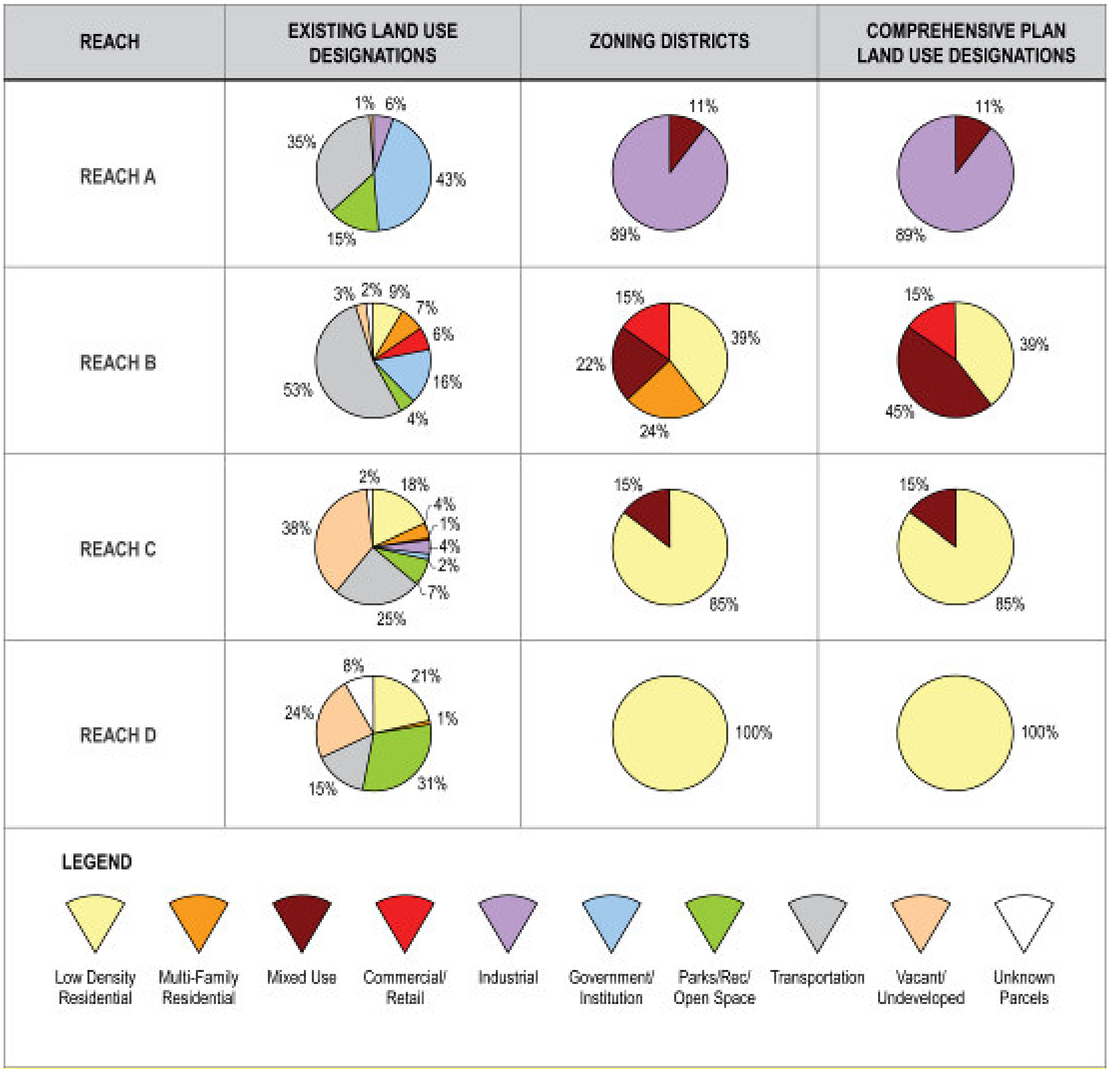

Figure 4-8 Percentages of Existing, Allowed and Planned Land Use by Reach in the Cedar River Shoreline Planning Area

A portion of the Renton Municipal Airport's shoreline frontage is considered a water-dependent use because it includes a seaplane dock on Lake Washington; however, none of the River frontage can be considered water-dependent. Most of the River's shoreline between Logan Avenue and I-405 is commercial or residential. There is a large vacant site on the north bank, east of I-405. This site was previously occupied by the Stoneway Concrete batch plant.

The River provides the most opportunity for public access of all the shoreline waterbodies in Renton. The Cedar River Trail and the numerous parks along the River provide the public with multiple opportunities to access and/or view the water.

Undeveloped or Vacant Lands

Table 4-9 provides the percentage of undeveloped parcels and undeveloped area by reach. As described above, a large portion of the Cedar River Greenway System in Reach C and D is incorrectly categorized as undeveloped area instead of parks, recreation, and open space.

Table 4-9. Existing Development of Waterfront Parcels along Cedar River

Reach	# of Lots	% Undeveloped Lots	% Undeveloped Area
CR-A	9	11%	1%
CR-B	62	11%	3%
CR-C	170	25%	38%
CR-D	64	19%	24%

Source: King County 2008; City of Renton 2008a

4.3.3.2 Impervious Areas

Impervious areas were analyzed based on the City's GIS layer. Table 4-10 below shows the total amount of impervious area for each reach within the Cedar River shoreline planning area. The impervious area only includes public ROWs and buildings.

Table 4-10. Impervious Surface in Cedar River Shoreline Planning Area

Reach	Total Acres	Impervious Area (Acres)	Percent Impervious	Roadway % of Total Impervious areas	Building % of Total Impervious Areas
A	79	30	38%	92%	8%
B	32	20	63%	82%	18%
C	168	48	28%	86%	14%
D	126	21	17%	90%	10%

Source: City of Renton 2005

Since the data does not reflect driveways and parking lots, the amount of impervious surface for some reaches is larger than is shown in the table. The following is a list of sites that contribute additional impervious area:

- Pavement at Renton Municipal Airport and Boeing Airport Company in Reach A
- Parking lots and driveways along Cedar River Trail and Renton Memorial High School Stadium in Reach A
- Compacted dirt at Stoneway Sand and Gravel site in Reach C

According to the data in the table, the vast majority of impervious surface adjacent to the River is roadways.

4.3.3.3 Public Access

The Cedar River provides significant opportunities for shoreline access. There is at least one park in every reach, with the exception of only the Cedar River Trail in Reach A. The Cedar River Trail is a pedestrian and bicycling trail that provides water-oriented recreation. It is located along the entire length of the River within the City limits. The trail continues upstream, beyond City limits, towards Maple Valley. Access to the trail in the City is located in Reach A via North Riverside Drive or the Renton Memorial High School Stadium. Additional access points are located at Reach C in Liberty Park, Cedar River Park, Riverview Park, and Maplewood Roadside Park; and Reach D at Ron Regis Park (City of Renton Parks and Recreation website 2008) (Map 12).

- **Cedar River Trail Park:** Located in Reach A on the east side of the River, the 24-acre Park provides parking, a non-motorized boat launch, restrooms and passive-use areas. The major feature of the Park is the Cedar River Trail, which starts at Lake Washington.
- **Jones Park:** Located in Reach B, the 1.2-acre Park includes a playground, picnic tables, benches, and restrooms. The Park does not provide physical access to Cedar River.
- **Liberty Park:** Located in Reach B, the 12-acre active recreation Park includes basketball courts, tennis courts, two fields with bleachers, picnic areas, shelters, playground equipment, a skate-park, and a large a parking lot with 180 stalls. The Park provides access to the Cedar River Trail.
- **The Renton Library:** Located in Reach B and spanning the River to the east of Bronson Way, the Library provides visual access to the river from walkways.
- **Riverview Park:** Located in Reach C, this 11-acre ark provides water-oriented recreation. Non-motorized boat launches provide the public with access to the shoreline. The Park also has restrooms, a picnic shelter, interpretive salmon life cycle displays, wildlife viewing, and open meadows along the Cedar River Trail.
- **Maplewood Park:** This active, one-acre park is located in Reach C. It functions as a gateway to the Cedar River Trail and provides access to the water.
- **Cedar River Natural Zone:** This 257-acre, undeveloped greenway is located along the southern bank of the River in Reach C. The Cedar River Trail partially travels through the greenway.
- **The Maplewood Golf Course:** This city-owned golf course located in Reach D. The golf course does not provide physical access to Cedar River.
- **Ron Regis Park:** Located in Reach D, this 45-acre Park provides 12½ acres of active recreation, including a baseball/softball field, soccer field, basketball court, restrooms and a parking lot with a 120 stalls. The remainder of the Park, located along Cedar River is left in its natural state. The park provides a soft-surface walkway to the Cedar River that was damaged by flows diverted by landslides in the 2001 earthquake. Though damaged, the walkway still provides access to the River.

Opportunities for enhanced public access by reach include:

- Reach A from the mouth to Logan Ave contains the Cedar River Trail Park on the east bank with a trail along the entire reach. There is no public access from the Municipal Airport to the east. The potential for redevelopment along this reach is very limited, unless the Boeing Plant should be redeveloped, which might lead to a change in the use of the Municipal Airport and the potential for public access as part of that redevelopment.
- Reach B extends from Logan Ave. to I-405. The public owns a corridor about 200 feet wide as part of the former Commercial Waterway District. There is a continuous trail system along the north side of the river. The Renton Senior Center and several parks are in this reach. Jones Park is 1.2-acres in size and includes a playground, picnic tables, benches and restrooms. Liberty Park is a 12-acre active recreation park that includes sports fields, picnic areas, playgrounds, and a skatepark. The Renton Library that spans the river east of Bronson Way provides visual access to the river from walkways. Future redevelopment of private land may provide opportunities for an enhanced area of public access and shoreline oriented

uses to enhance shoreline enjoyment. The city park maintenance facility along the river may be redeveloped to provide additional recreation opportunities. Revisions to the existing trail to relocate further from the water's edge to allow revegetation should be considered in the future as part of park and river maintenance plans.

- Reach C is located between I-405 and SR 169 and contains the Cedar River Trail on the former Milwaukee Road Railroad ROW. Riverview Park: is located on the north side of the river and provides a non-motorized boat launch and public shoreline access as well as a picnic shelter, interpretive salmon life cycle displays, wildlife viewing, and open meadows along the Cedar River Trail. Maplewood Park is an active one-acre park that functions as a gateway to the Cedar River Trail and provides access to the water. The Cedar River Greenway System is a 237-acre undeveloped greenway located along the southern bank. Private redevelopment of the former Stoneway Cement plant east of Riverview Park, the Riviera Apartments, and other properties with high intensity zoning provides opportunities for enhanced public access parallel to the shoreline as well as shoreline ecological enhancement and possibly water-oriented development. There is some single-family development in the area that provides little opportunity for enhanced public access except through public acquisition.
- Reach D between SR 169 and the City limits contains the Maplewood Golf Course and Ron Regis Park. There is no public access along the river adjacent to the golf course. Whereas Ron Regis Park provides a soft-surface walkway to the Cedar River that was damaged by flows diverted by landslides in the 2001 earthquake, but remains accessible. Public shoreline access in this area should be balanced with ecological values. There are several spawning channels that have been developed along this reach to enhance fish habitat. The Cedar River Trail in this area is alongside SR 169 but provides access to the Cedar River further upstream and downstream. There is limited private land in this reach and little potential for redevelopment that might include public access.

4.3.3.4 Infrastructure

Numerous bridges span the Cedar River within Renton city limits. Most of these crossings occur within Reach B, including two private bridges connecting the Boeing Airplane Company with the Renton Municipal Airport, the Williams Avenue Bridge, the Wells Avenue Bridge, the Bronson Way Bridge, the Houser Way Bridge, the Renton Public Library and the BNSF railroad tracks. Logan Avenue, a six-lane principal arterial, spans the river in Reach A. I-405 crosses the River in Reach C as does a pedestrian bridge beneath the I-405 bridge and a pedestrian bridge carrying the Cedar River Trail. SR 169 (Renton Maple Valley Road), a principal arterial, and 149th Avenue cross the river in Reach D with the Cedar River Trail utilizing the old highway bridge.

There are also several roads that travel parallel to the river within the shoreline planning area, including streets on both sides of the river between Williams and Wells Avenues and continuing along the north bank to Bronson Way. There are 25 stormwater outfalls along the Cedar River in Reaches A, B, and C recorded in the City of Renton inventory (City of Renton 2008b; King County 2002) (Map 9b). It is likely that there are additional, unrecorded outfalls from both the street system and adjacent development.

4.3.3.5 Historic and Cultural Resources

Native American and Euro-American historic use of the area is detailed in Section 4.1.4.5 (Historic and Cultural Resources – Lake Washington).

A search of the DAHP database indicated that there are two state- and federally-registered sites near the River shoreline planning area as described in Table 4-11:

Table 4-11. Registered Sites near Cedar River Shoreline Planning Area

Name	Location	Year Built	Description
Renton Substation Snoqualmie Falls Power Company (45-KI-74)	1017 South 3rd Street	1898	Energy Facility
Renton Fire Station (45-KI-209)	235 Mill Avenue South	1939	Government fire station

Source: DAHP 2008b and 2008c

The DAHP database also indicated that there are two inventoried sites near the Cedar River shoreline planning area as described in Table 4-12:

Table 4-12. Inventoried Sites near Cedar River Shoreline Planning Area

Name	General Location	Date	Description	National Register of Historic Places (NRHP) Eligibility Determination
Henry Moses Aquatic Center (45-KI-686)	Northeast side of the Cedar River channel	291 before present (BP)	Two hearths and other archaeological materials. Site was used as a traveling campsite for resource gathering or trading groups traveling along the Cedar River Pack Trail.	Eligible but has been completely removed through controlled excavation
Historic debris scatter (45-KI-542)	South bank of the Cedar River	Not provided	Several hundred bricks, drainage tiles, RR-tie-sized boards, two cart wheels, one axle, and slabs of aluminum siding and roofing.	Not determined

Source: LAAS 2003b; NWAA 2007; Norman 1996

A cultural resource report prepared by Historical Research Associates in October 2005 for a Bonneville Power Administration (BPA) project identified three ethnographic sites.

- A Duwamish Tribe fish weir and trading ground located at the present site of Maplewood Golf Course.
- A Duwamish Tribal village west of Maplewood Golf Course, along the Cedar River in the vicinity of Maplewood Village.
- The historic period trail from Seattle to the Cascade Mountains, also called the Cedar River Pack Trail.

The Cedar River falls within the recognized usual and accustomed fishing grounds and stations of the Muckleshoot Tribe.

4.4 GREEN RIVER

4.4.1 General Conditions

As indicated in the watershed analysis in Section 3.1, only a small portion of the 566-square-mile Green River watershed is within the City. Most of the Green River watershed within the City is within the Springbrook Creek watershed, discussed below. For the purposes of this analysis, the portion of the Black River downstream of the pump station is considered part of the Green River, since most of its hydrologic functions are related to the adjacent Green River. With the exception of the Black River spur, the entire Green River channel is separated from the City by the BNSF railway mainline that parallels the river. Except for the Black River, areas within the City that are within the SMA jurisdiction include slivers of land adjacent to the railway where the River meanders to the east.

4.4.2 Hydrological and Biological Resources

4.4.2.1 Tributaries and Associated Wetlands

The Black River below the pump station is the only portion of the Green River within the shoreline planning area that has a hydraulic connection to the river. Although most of the historic floodplain was likely wetland, the channel has been realigned and no wetlands are known to occur within the shoreline planning area (see Map 3a). Small wetlands may be present that have not yet been identified or mapped.

4.4.2.2 Fish and Wildlife Presence

No priority habitats for wildlife were identified within the shoreline planning area, although two bald eagle nests are located within ½ mile of the shoreline (see Map 5c). The eastern section of the planning area falls within the Black River Riparian Forest conservation area, although the width of the protected corridor on either side of the Black River is less than 150 feet.

Chinook, Coho, Chum, Pink, Steelhead, and Cutthroat are all found in the Green River (see Map 5a), and life histories are similar to those described for the Cedar River (see Section 4.3.1.3). Pink and Chum salmon typically migrate directly to saltwater upon emergence. Other species use the City's shorelines primary for migration and rearing. The Muckleshoot Tribes

4.4.2.3 Instream and Riparian Habitat

The riparian corridor is typically less than 100 feet wide on either side of the Black River below the pump station and is composed of small- to medium-sized deciduous trees and emergent vegetation. Roads, paths, and industrial development limit the width, and, on the right bank, bisect vegetative cover. Reed canarygrass (*Phalaris arundinacea*) cover is very common to dominant. LWD recruitment potential is low.

The Black River is channelized and is almost exclusively glide habitat, providing little habitat complexity or foraging potential or cover for either fish or wildlife.

Upstream of the Black River, a very thin sliver of Green River shoreline planning area lies within Renton city limits. This area includes only riparian habitat. The shoreline is isolated from the River by a railroad levee and does not contain any natural cover or support any ecological function.

4.4.2.4 Other Natural Features

The lower portion of the Black River is identified as part of the Green River shoreline planning area specifically because a portion of the floodplain is still connected (see Map 4c). City critical areas maps do not identify these areas as aquifer recharge zones.

Landslide, erosion, and coal mine hazards are not present on the shoreline, but alluvial deposits underlying the entire Green and Black River floodplains present a seismic hazard (see Map 4a).

4.4.2.5 Floodplain and Channel Migration

Flood hazards within the Green/Duwamish River system have been actively managed since the turn of the $10^{th}/20^{th}$ Centuries by (a) diversion of the White River into the Puyallup drainage, (b) lowering Lake Washington, and diversion of the Cedar River (c) installation of the Howard A. Hanson Dam, and (d) the installation of levees and revetments.

Current floodplain studies indicate that extensive flooding would occur in a major event, largely because the Green River levee system is no longer credited with providing 100-year flood protection along the entire reach of the Green except for levees protecting the Southcenter area. Current Green River flood plain information is indicated in Map 4f.

The King County Flood Control Zone District (KCFCZD) was established in 2007 to implement the 2006 King County Flood Hazard Management Plan (KCFHMP) and assumed the assets and responsibilities of the previous ten individual flood control zone districts. The flood hazard management plan includes a comprehensive program to update the flood control program for the Green River, but in the short to medium term, the risk of flooding from the Green River can be expected over a large portion of the City of Renton to the east of the river.

The channel migration zones of the Green river prior to European Settlement likely meandered over much of the valley floor (Collins and Sheikh, 2005). The river is currently constrained by the installation of levees and/or revetments along most of the channel banks adjacent to the city. Although some of those levees are not federally-certified, the presence of these features as well as roads and railroads parallel to the river results in little or no potential for channel migration into Renton.

4.4.3 Built Environment

4.4.3.1 Existing and Planned Land-Use

Existing Land-Use

Land-use patterns along the shoreline of the Green River are a mix of industrial, roadways, government/institutional, commercial/retail, and undeveloped lands. Existing land-use was assessed using 2008 King County Assessor's parcel data. The majority of the Green River shoreline is designated as industrial (45 percent), with the remainder as roadways and railroads (19 percent), government/institutional (13 percent), commercial/retail (12 percent), and undeveloped lands (11 percent). A portion of the Black River Riparian Forest and Wetland has been misclassified as undeveloped lands instead of parks, recreation and open space. The industrial designation includes the Columbia Distributing Company, a beer and wine distribution facility.

There are three areas in the City of Renton adjacent to the Tukwila city limits that are within SMA jurisdiction as measured by the 200-foot jurisdiction boundary from portions of the Green River. All of these areas are separated from the river by the BNSF railroad.

Planned Land-Use

The City has designated the Green River shoreline planning area as Employment Area Valley with Medium Industrial and Resource Conservation zoning. Figure 4-9 shows the proportions of current land-use, zoning and Comprehensive Plan land-use designations for the Green River shoreline. The data for city zoning and Comprehensive Plan land-use exclude roadways and railroads. Roads and railroads, categorized as transportation, are included in the existing land-use data.

The Renton Comprehensive Plan designation for the entire Black River/Springbrook Creek area is Employment Area-Valley. It is categorized as Commercial below for consistency with the King County Assessor's land-use coding.

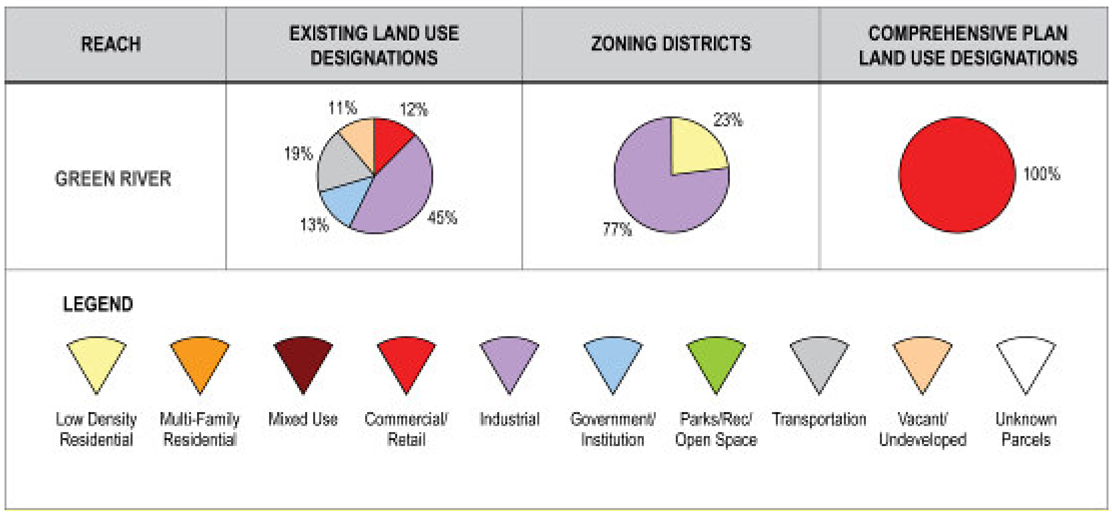

Figure 4-9 Percentages of Existing, Allowed and Planned Land Use by Reach in the Green River Shoreline Planning Area

The only water-dependent use in the Green River shoreline planning area occurs on behalf of the Muckleshoot Indian Tribe that fishes the River's mainstream. A review of King County Assessor's data revealed that there are several commercial and industrial properties along the Green River, but these properties do not involve any water-dependent or water-related uses. Public access is provided through the Black River Riparian Forest and Wetland.

Vacant Lands

Table 4-13 provides the percentage of undeveloped parcels and undeveloped area. As described earlier, a portion of undeveloped area is part of the Black River Riparian Forest and Wetland.

Table 4-13. Existing Development of Waterfront Parcels along Green River

Reach	# of Lots	% Undeveloped Lots	% Undeveloped Area
GR-A	27	33%	11%

Source: King County 2008; City of Renton 2008a

4.4.3.2 Impervious Areas

Impervious areas were analyzed based on the City's GIS layer. Table 4-14 below shows the total amount of impervious area for the Green River shoreline planning area. The impervious area only includes public ROWs and buildings. Most impervious area is due to Monster Road Southwest.

Table 4-14. Impervious Area for the Green River Shoreline Planning Area

Reach	Total Acres	Impervious Area (Acres)	Percent Impervious	Roadway % of Total Impervious areas	Building % of Total Impervious Areas
A	29	7	23%	22%	18%

Source: City of Renton 2005

4.4.3.3 Public Access

There is no public access to the Green River shoreline within Renton city limits. The Duwamish Green River Trail located along the Green River in Tukwila provides visual access to the Green River shoreline (City of Tukwila Parks and Recreation website 2008).

The area of the Black River west of Monster Road provides no public access. There may be opportunities to establish public physical access from a trail parallel to the water as private lands redevelop. Public agency actions to improve public access should include acquisition of trail rights to connect the trail system to the Green River Trail and Fort Dent park including crossing under the railroad tracks.

4.4.3.4 Infrastructure

Monster Road, a principal arterial, crosses over the Black River within the Green River shoreline planning area. BNSF railroad tracks are located within the Green River shoreline planning area. There are no stormwater or wastewater outfalls along the Green River within the City limits recorded in the City's inventory (Map 9b). (City of Renton 2008b; King County 2002). It is likely that there are unrecorded outfalls primarily from both the street system that are culverted under the BNSF railway.

4.4.3.5 Historic and Cultural Resources

Native American and Euro-American historic use of the Renton area is detailed in Section 4.1.4.5 (Historic and Cultural Resources – Lake Washington). A search of the DAHP database indicated that there are no state- or federally-registered sites, nor are there any inventoried sites within the Green River shoreline planning area.

The Green River falls within the recognized usual and accustomed fishing grounds and stations of the Muckleshoot Tribe.

4.5 BLACK RIVER/SPRINGBROOK CREEK

4.5.1 General Conditions

Springbrook Creek is the largest subbasin in the lower Green River Basin, with a watershed area of about 15,763 acres (24.6 square miles). The basin is composed of two distinct physical settings. In the eastern half of the subbasin, rolling hills rise to elevations of about 525 feet above the valley floor. The western half of the basin is virtually flat.

The creek is 12 miles long with about 3.5 miles in the City. Tributaries, Mill and Garrison Creeks, enter from the south from the City of Kent. Panther Creek and Rolling Hills Creek originate on plateaus to the east with headwaters at Panther Lake and flow into Springbrook Creek near Southwest 30th Street. Only the mainstem of Springbrook Creek is within SMA jurisdiction, together with associated wetlands.

All of Springbrook Creek in the City was extensively modified and straightened for agricultural drainage in the 1920s by King County Drainage District No. 1, which owns the Springbrook Creek ROW. The channel area from the Black River Pump Station, including Forebay area up to the Oakesdale bridge crossing just upstream of Southwest 16th Street, was improved in the 1980s and 1990s for flood control by the City in cooperation with the Natural Resource Conservation Service (formerly the Soil Conservation Service; Straka 2008).

The pump station prevents high flows in the Green River from backing up into Springbrook Creek, reducing the risk of flooding. The pump station is a barrier to salmonids upstream and downstream during certain seasons, and is in need of replacement to avoid obstructing fish passage (Kerwin and Nelson 2000).

4.5.2 Hydrological and Biological Resources

4.5.2.1 Tributaries and Associated Wetlands

Black River/Springbrook Creek now is a stream system that flows parallel to the Green River and about a half mile to the east. As discussed in Section 3.1.2, the Black River previously was part of the Cedar River system and conveyed the flows of the Cedar River to the Green River. In 1916, Cedar River discharge was diverted from the Black River to Lake Washington due to lowering of Lake Washington. The portions of the Black River east of Springbrook Creek dried up or were filled and the Black River is simply an archaic label for the downstream reaches of the Springbrook Creek system.

The major tributaries to Springbrook Creek include Rolling Hills Creek and Panther Creek. Rolling Hills Creek flows west into Springbrook Creek along Southwest 23rd Street in a piped conveyance (see Map 3a). Approximately the first 3,000 feet of stream is piped. Jones and Stokes (2005) identify Rolling Hills Creek as perennial but non-salmonid bearing. Just upstream, Panther Creek flows west into Springbrook Creek via its primary channel and a piped distributary. Panther Creek supports Coho and Cutthroat according to Williams et al. (1975), but WRIA 9 literature does not identify direct observation of existing use by Coho (Kerwin and Nelson 2000). A small, unnamed, ephemeral tributary flows east and enters Springbrook Creek between Rolling Hills and Panther Creeks. The stream is non-salmonid bearing. According to the Muckleshoot Tribes fisheries division, Springbrook Creek is used by all salmonid species except Sockeye Salmon (MIFTD 2009).

Black River/Springbrook Creek flows through what was historically the Green River floodplain, which deposited alluvium that supported large riparian wetlands. Some of these wetlands still exist today. A large, forested wetland also exists along the Black River paleochannel in Reach A (see Map 1d). In addition, the impoundment created upstream of the flood control structure creates an area of open water catalogued by the National Wetland Inventory.

Another wetland complex can be found downstream surrounding the Springbrook and Panther Creek confluence. To the west, a forested wetland runs along the right bank of Springbrook Creek and up both banks of Panther Creek. An additional emergent wetland lies on the west side of Springbrook Creek.

In addition, the Washington State Department of Transportation (WSDOT) and the City implemented a joint, multi-site wetland mitigation bank that includes 130 acres of wetland restoration, rehabilitation, and enhancement (WSDOT 2008; Figure 4-10). Three of these sites are contiguous to Springbrook Creek, and the other two sites are potentially associated with (and may be within) the shoreline planning jurisdiction. The mitigation bank sites are located between Southwest 27th Street and the City limits at Southwest 43rd Street. Other wetlands may occur in the area that have not yet been identified or mapped.

4.5.2.2 Fish and Wildlife Presence

Chinook, Chum, Coho, Steelhead Trout, and Cutthroat Trout are all found in Black River/Springbrook Creek and utilize the habitat primarily for migration (see Maps 5a and 5b). However, Coho are the only anadromous salmonids to use the stream extensively. With the exception of Chum, salmonids may also use the Black River for rearing to a limited extent. Kerwin and Nelson (2000) report that Chinook use is likely exploratory, and the system does not support substantial use. The portion of Black River/Springbrook Creek within the shoreline jurisdiction is very low gradient, and existing habitat is not likely to support substantial spawning.

4.5.2.3 Instream and Riparian Habitat

Instream habitat in the Springbrook Creek shoreline is extremely uniform (Table 4-15) and virtually identical across reaches. The Black River Basin plan (City of Renton 1993) notes that under present conditions the lack of suitable spawning habitat and questionable rearing capacity due to degraded water quality, especially high temperatures during warm summer months, provides little usable fish habitat (Kerwin and Nelson 2000). These limiting conditions remain today. The stream is constrained and channelized throughout the shoreline. The stream gradient is very flat, sinuosity is very low, and the stream has been almost completely straightened in Reach C, reducing channel surface area (usable habitat) thereby limiting habitat creation.

Reach A has been impounded by the Black River flood control structure, and much of the reach is contained in a large pond that is prone to increased temperature and corresponding low DO. Temperature may present a barrier for migrating salmonids. Impaired temperature and DO have degraded salmonid rearing and, in upstream reaches, have inhibited incubation. The Black River Pumping Station (BRPS) can act as a barrier to migration of juvenile and adult salmonids due to inadequate screening, fishway design, and operation schedule (Kerwin and Nelson 2001). The riparian corridor in this reach is primarily forested and more than 250-feet-wide on either bank. However, invasive reed canarygrass is also dominant in areas, particularly on the river's left shoreline where public access and a trail system exist.

Table 4-15. Habitat Types in Springbrook Creek

Habitat Type	Length (ft)	Percent of Total
All Potential Habitat	30,645	100
Steps	40	<1
Pools	54	<1
Riffles	4174	13
Glides	0	0
Low Gradient Glides	25304	83
Habitats Not Delineated	1073	4

Source: Harza (1995)

Upstream of Oakesdale Avenue, the stream flows through a 100- to 150-foot-wide vegetated corridor, bounded on either side by roads and industrial/commercial development. A combination of deciduous forest and open canopy emergent areas extend 30 feet on the east (left) bank and 80-100 feet on the west (right) bank.

In Reach B the stream then flows under two local streets and I-405, which has caused a highly disturbed riparian condition.

Portions of the riparian corridor in Reach C have undergone restoration and have a somewhat natural character with a vegetated riparian corridor within in the Boeing Longacres Office Park. The vegetated riparian corridor width in this area varies between 75 and more than 200 feet to either side of the stream. A wetland bank includes restoration of an extensive area adjacent to the channel and involves several breaches of the existing berm and riparian plantings of native vegetation in Units A, B, and E (Fibure 4-10). Over half of the stream in Reach C is maintained as a straight bermed ditch by the Drainage District. The district regularly removes vegetation within the channelized portions of the stream and the vegetation cover is dominated by reed canarygrass. The character of the stream and maintenance practices contribute to continuing cumulative trends of decline in ecological functions through blocking of groundwater interflow that would otherwise contribute lower temperature water inputs, lack of riparian vegetation necessary for shading to maintain temperature, providing organic inputs critical for aquatic life including the food chain, filtering and vegetative uptake of nutrients and pollutants from groundwater and surface runoff, regulating of microclimate in the stream-riparian corridors, and other functions.

4.5.2.4 Floodplain and Channel Migration

The Springbrook Creek floodplain has been delineated in Federal Emergency Management Agency (FEMA) studies and maps (FEMA 2007) as well as additional studies by the City of Renton (RW Beck 2006). Floodplains indicated on Map 4g include the areas flooded by the Green River. The floodplain of Springbook Creek itself as indicated in the 2006 RW Beck study is contained within the maintained channel except within the Black River Forest wetlands, wetlands just north of the Panther Creek confluence, wetlands in the WSDOT mitigation bank, some wetlands preserved as part of the Longacres Office Park south of 27th Street and west of Oaksdale Avenue and a small area adjacent to the railroad south of the BNSF automobile facility. The floodway is entirely within the maintained channel. Flood events from the Green River at a level somewhat below the 1 percent or 100 year flood are prevented from extending up Springbrook Creek by the Black River Pump Station. Large floods from the Green River, however, are of greater depth than the Springbrook Creek/Black

River floodplain and override the extent of the creeks floodplain and cover a much larger area. The Green River floods, however, are from overtopping levees further upstream that are carried down the valley and are not from lateral overtopping of the levees adjacent to Renton.

Under natural conditions, the channel migration zone for Springbrook Creek probably included a meander zone across the valley. It is now constrained both by the channel maintained by the Drainage District and by public streets and development. For all practical purposes, the creek has no channel migration zone.

4.5.2.5 Other Natural Features

The entire shoreline is underlain by Green River alluvium that supports a shallow aquifer and is at risk to liquefaction during an earthquake (see Map 4a). This land is not identified in the City's critical areas mapping as an important aquifer recharge area (see Map 4c). Downstream of 30th Avenue, frequently-flooded areas are extensive and are comprised of primarily existing wetlands and other open space (see Map 4c). No erosional or landslide hazard areas are present within the shoreline planning area.

4.5.2.6 Existing and Planned Land-Use

Existing Land-Use

Land-use patterns along the shoreline of Black River/Springbrook Creek are a mix of undeveloped lands, industrial, roadways, commercial/retail, parks, recreation and open space, and government/institutional. Existing land-use was assessed using 2008 King County Assessor's parcel data.

- **Reach A:** The majority of Reach A is designated as undeveloped (38 percent), with the remainder as roadways (22 percent); parks, recreation, and open space (22 percent); government/institutional (12 percent); and commercial/retail (six percent). The parks, recreation, and open space classification only partially includes the Black River Riparian Forest and Wetland and the Metro Waterworks Garden Park. The remainder of the Park is incorrectly classified as undeveloped. The King County South Treatment Plant, classified as government/institutional, is a regional wastewater treatment plant. It treats wastewater from properties located along the east side of Lake Washington between Snohomish and Pierce Counties (King County Natural Resources and Parks website 2008a).
- **Reach B:** This Reach is composed of largely of right of way as the stream crosses Grady Way and I-405. There is a small component of light-industrial and office park west of the stream.
- **Reach C:** This Reach is composed of industrial (47 percent); parks, recreation, and open space (29 percent); commercial (10 percent); roadway (nine percent); and undeveloped (five percent) land-uses. In addition to Boeing Longacres Office Park, the industrial and commercial land-uses are attributed to Springbrook Industrial Center, an industrial office park. Located in between Southwest 27th and Southwest 34th Street, Springbrook Creek Wetland and Habitat Mitigation Bank are incorrectly classified as undeveloped. The Mitigation Bank is a joint effort between WSDOT and the City to enhance over 130 acres of wetlands. The enhancement site serves as mitigation for impacts resulting from highway construction and City development projects (WSDOT website 2008).

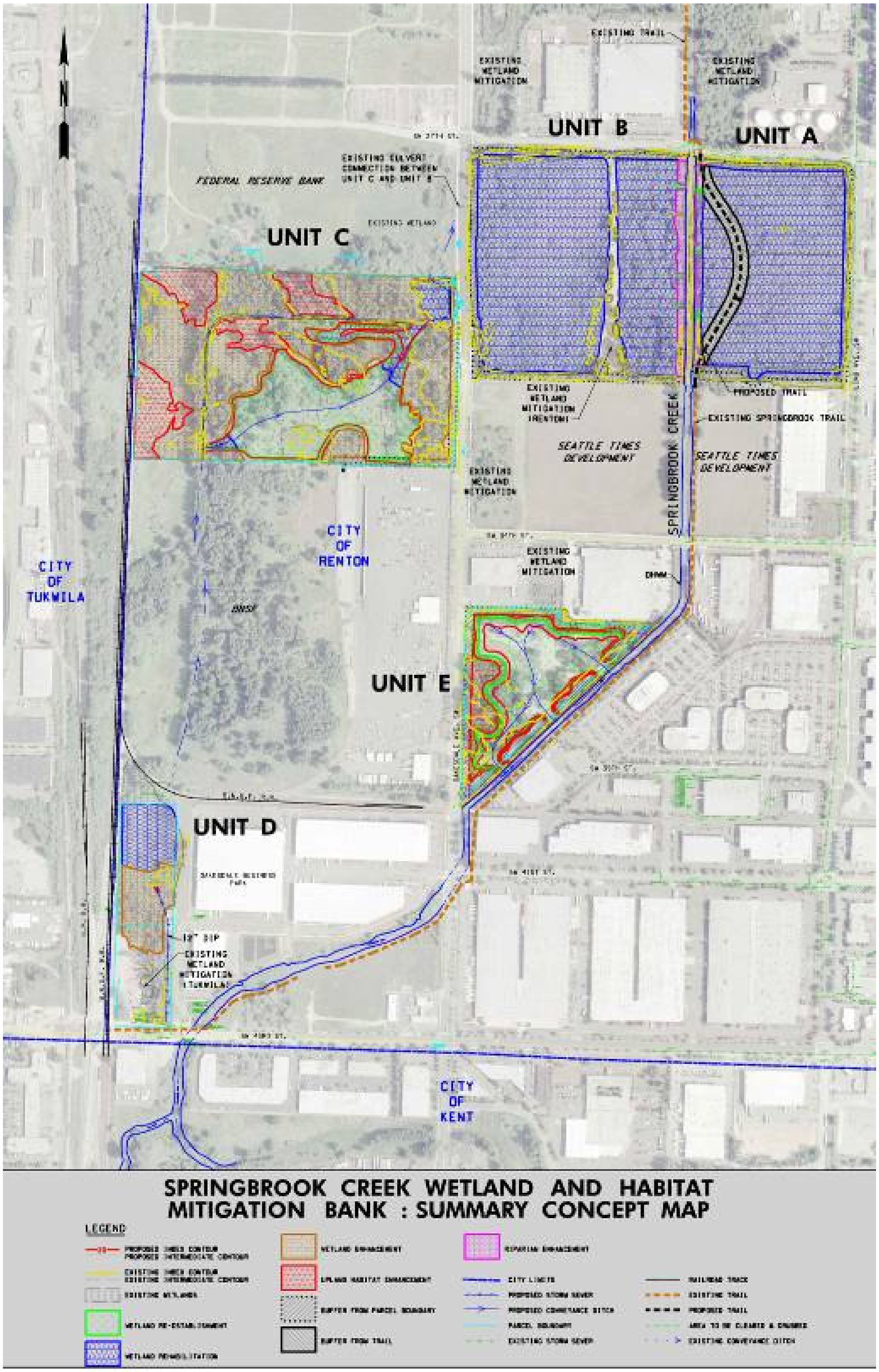

Figure 4-10 City of Renton/WSDOT Wetland Mitigation Bank Site Map

Planned Land-Use

The City's zoning and Comprehensive Plan land-use designations are Low Density Residential, Industrial, and Commercial Uses (City of Renton 2008b).

Figure 4-11 shows the proportions of current land-use, zoning, and Comprehensive Plan land-use designations for each Black River/Springbrook Creek shoreline reach. The data for City zoning and Comprehensive Plan land-use exclude roadways. Roads, categorized as transportation, are included in the existing land-use data. City zoning is Resource Conservation, Commercial Office, Industrial Light, Industrial Medium, and Industrial Heavy. The Renton Comprehensive Plan designation for the entire Black River/Springbrook Creek area is Employment Area - Valley. It is categorized as Commercial below for consistency with the King County Assessor's land-use coding.

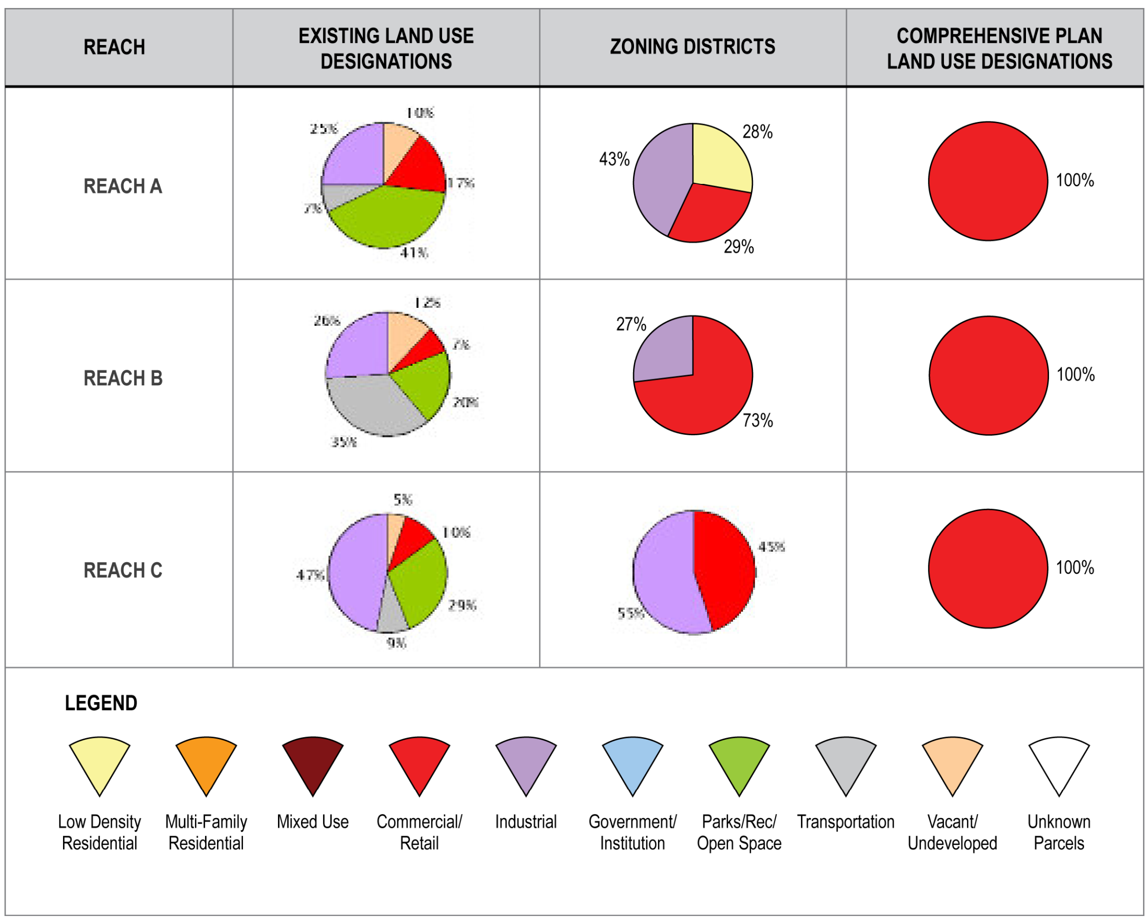

Figure 4-11 Percentages of Existing, Allowed and Planned Land Use by Reach in the Black River/Springbrook Creek Shoreline Planning Area

The Black River/Springbrook Creek shoreline does not have any water-dependent uses. A review of King County Assessor's data revealed that there are several commercial and industrial properties along Black River/Springbrook Creek. The properties do not involve any water-dependent or water-related uses. Public access is provided through the Black River Riparian Forest and Wetland, the Metro Waterworks Garden Park, and Springbrook Trail.

Undeveloped or Vacant Lands

Table 4-16 provides the percentage of undeveloped parcels and undeveloped area by reach. As described earlier, a large portion of undeveloped area in Reach A is part of the Black River Riparian Forest and Wetland and the Metro Waterworks Garden Park. Undeveloped area in Reach C is, to a large extent, part of the Springbrook Creek Wetland and Habitat Mitigation Bank.

Table 4-16. Existing Development of Waterfront Parcels along Black River/Springbrook Creek

Reach	# of Lots	% Undeveloped Lots	% Undeveloped Area
BRS-A	45	47%	38%
BRS-B	9	22%	1%
BRS-C	58	21%	31%

Source: King County 2008; City of Renton 2008a

4.5.2.7 Impervious Areas

Impervious areas were analyzed based on the City's GIS layer. Table 4-17 below shows the total amount of impervious area for each reach within the Black River/Springbrook Creek shoreline planning area. The impervious area only includes public ROWs and buildings.

Table 4-17. Impervious Surface in Black River/Springbrook Creek Shoreline Planning Area

Reach	Total Acres	Impervious Area (Acres)	Percent Impervious	Roadway % of Total Impervious areas	Building % of Total Impervious Areas
A	66	12	19%	99%	1%
B	8	3	34%	76%	24%
C	130	18	14%	61%	39%

Source: City of Renton 2005

Because the data does not reflect parking for industrial and commercial properties along the Black River/Springbrook Creek shoreline, the amount of impervious surface for some reaches is more than shown in the table. According to the data in the table, the largest source of impervious surface along Black River/Springbrook Creek is roadway.

4.5.2.8 Public Access

There are several opportunities along Black River/Springbrook Creek to access the shoreline (City of Renton Parks and Recreation website 2008; King County Natural Resources and Parks 2008b).

- **Black River Riparian Forest and Wetland:** Located in Reaches A and B, the Park offers 92 acres of bird-watching and trails.
- **Waterworks Garden Park:** Located next to the King County South Treatment Plant in Reaches A and B. The Park includes trails, public art, ponds, marshes, and access to Springbrook Trail.
- **Springbrook Trail:** A two-mile pedestrian and bicycling trail that travels along the entire length of Springbrook Creek.

Opportunities for enhanced public access by reach include:

- **Reach A** extends from the pumping station to Grady Way and is largely in public ownership including the Black River Riparian Forest and Wetland and the Metro Wastewater Treatment Facility (WWTF). In addition to the Riparian Forest and Wetland, Metro maintains the Waterworks Garden Park. There is a public access trail adjacent to the stream adjacent to the WWTF. There also is a pedestrian sidewalk on Oakesdale Avenue which is immediately east of the creek and adjacent to the wooded buffer area.
- **Reach B** from Grady Way to SW 16th Street includes a trail system on WSDOT right of way that crosses under I-405. Opportunities for enhancement may be presented as part of future highway improvements or other public agency actions.
- **Reach C** extends from SW 16th Street to city limits and includes two public trails that are separated by industrial, office, and commercial uses. The first trail was developed as part of the Boeing Longacres Office Park and parallels the stream from SW 16th Street under Oaksdale until 19th Street at the parking lot of a pre-existing industrial building. From 23rd Street to the south, the City of Renton maintains a trail which runs south through the entire corridor. The WSDOT wetland mitigation bank in the drainage provides some interpretive access.

4.5.2.9 Infrastructure

Within City limits, Black River/Springbrook Creek is crossed by five bridges and culverted or piped under five roadways. Most crossings occur in Reach C. Monster Road, a principal arterial, crosses over the stream on bridges in Reach A. In Reach B Grady Avenue and I-405 cross the stream on bridges. In Reach C, the stream is culverted under 16th Street, it is crossed by Oakesdale Avenue on a bridge and is culverted at 27th Street, bridged at 34th Street, culverted diagonally from the railroad at about 40th street across Oaksdale Avenue to south of 41st Street and culverted under 43rd Street at the city limits. There are 19 stormwater outfalls and two wastewater outfalls along Black River/Springbrook Creek recorded in the City's inventory(Map 9b) (City of Renton 2008b; King County 2002). There are numerous City water and sewer crossings of Springbrook Creek. King County sewer interceptors also cross and are near Springbrook Creek. Seattle Public Utilities has a waterline crossing at southwest 23rd Street. Olympic pipeline crossings are also in the area. The British Petroleum Oil Tank Farm is also located adjacent to Springbrook Creek (Straka 2008). Finally, it is likely that there are additional, unrecorded outfalls from both the street system and private development.

4.5.2.10 Historic and Cultural Resources

Native American and Euro-American historic use of the Renton area is detailed in Section 4.1.4.5 (Historic and Cultural Resources – Lake Washington). The heart of Duwamish settlement was on the former Black River, where the Tribe had several winter houses on both sides of the River. Many of the houses were built near fish weirs. This area was the densest concentration of Duwamish villages in Duwamish territory until 1916, when the lowering of Lake Washington eliminated the Black River. Tribe members that lived along the Cedar River, White River, and Green River came to the Black River each year to harvest salmon. This helped maintain the influential social and political status of the Black River villages (LAAS 1996b, 2003a and 2004).

The Duwamish applied names to natural features, watercourses, and other places that were important to them for geographic, spiritual, and economic reasons. There are a number of ethnographic place names for areas within the Black River/Springbrook Creek shoreline planning area. Swa'wa tix ted (now known as Surge Tank Hill) means isolated knoll or the old ground. The Duwamish name for Springbrook Creek is bibtičəd, which means a burden or load. This is a reference to a story about a woman who carried a load with a packstrap and threw the packstrap away, forming a small hill (LAAS 2003a and 2004).

A search of the DAHP database indicated the following:

- There are no state- or federally-registered sites within the Black River/Springbrook Creek shoreline planning area.
- There are five inventoried sites near the Black River/Springbrook Creek shoreline planning area as described in Table 4-18.
- There are three ethnographic sites. An extensive trail system radiated from the villages along the Black River to and from Snoqualmie Falls, Yakima Pass, Muckleshoot Prairie, and Elliott Bay. The Duwamish village Sqoa'lqo meaning 'meeting of the rivers' was at the confluence of the Black and White River. This village is partially-represented by the White Lake Site (described in Table 4-18 above). It was discovered during excavation for a King County utility project. A swamp area west of the King County Waterworks project was an important source of medicinal and edible plant materials and waterfowl for Native American people (LAAS 1996a and 1996b).

Table 4-18. Inventoried Sites near Black River/Springbrook Creek Shoreline Planning Area

Name	General Location	Date	Description	National Register of Historic Places (NRHP) Eligibility Determination
White Lake site (45-KI-438 and 45-KI-438A)	Near Fort Dent Park, west of the Black River	Not provided	Two shell-bearing cultural layers which had charcoal, fire modified rock, fish and mammal bone and lithic artifacts. Fragment of modified bone and two pieces of folded copper believed to be associated with fishhook manufacturing were also found.	Eligible but cultural materials were excavated to avoid impacts from a King County utility project
Tualdad Altu (45-KI-59)	East of the Black River	1400 years ago	Village with hearths, midden and artifacts	Excavated in the late 1970s and 1980s
Swa' wa tix təd (45-KI-267)	Surge Tank Hill near Monster Road	4,000 to 8,000 years ago	Cobble tools, siltstone flakes and chunks appearing to be derived from an Olcott occupation.	Eligible
45-KI-2	West of the Black River	Not provided	Shell midden/fish weir complex	Destroyed
Historic Object (45-KI-730)	Near Springbrook Creek at SW 27^{th} Street and Oakesdale Avenue	Object may have been associated with 1930s era Longacres Racetrack	A concrete basin or trough. Function unknown, but possibly associated with livestock or agricultural use.	Not discussed

Sources: LAAS 1996a, 1996b, and 2004; NWAA 2007; Cascadia Archaeology 2006; Kennedy 1985; Dampf et al. 2005

The Black River/Springbrook Creek area falls within the recognized usual and accustomed fishing grounds and stations of the Muckleshoot Tribe.

4.6 LAKE DESIRE

4.6.1 General Conditions

Lake Desire is comprised of mixed and deciduous forest interspersed with residential lots. Along the north and southeast reaches of the lake’s shoreline are natural areas; the entire shoreline has medium-high ecological function for LWD quality.

4.6.2 Hydrological and Biological Resources

Biological function is affected by residential development along the Lake Desire shoreline, but significant areas of open space exist along the north and southeast lakeshore. These areas provide important habitat and other ecological functions enhanced by their place in a larger network of natural areas. Contiguous parks and protected areas include Lake Desire Natural

Area, McGarvey Park Open Space, and Petrovisky Park. These conditions help the Lake Desire shoreline sustain a high level of ecological function (Table 4-19).

The Lake Desire watershed is designated by King County as a critical lake watershed due to the annual whole-lake total phosphorus concentration of 49 mg/l, its status as a eutrophic lake and modeling of future trophic status that indicates that the lake will become hypereutrophic with a future summer whole-lake total phosphorus concentration predicted to be 114 micrograms/liter.

The King County Lake Desire Management plan goal is improving the lake's existing trophic status through requiring that 50 percent of total phosphorus loading be removed from all new development prior to discharge to any drainage that enters Lake Desire and construction of an in-lake aeration system. (KCPNR 1996)

Table 4-19. King County Shoreline Ecological Function Ratings for Lake Desire

Shoreline	Light	LWD	Nitrogen	Pathogen	Phosphorus	Sediment	Toxins	Hydrology	Wave Energy
North	4	4	5	5	5	4	5	5	4
East	4	4	5	4	4	4	4	4	4
West	4	4	5	5	5	4	4	4	4

1=Low; 2=Low-Medium; 3=Medium; 4=Medium-High; 5=High
Source: King County (2008).

4.6.2.1 Tributaries and Associated Wetlands

Lake Desire is fed by two small tributaries, one each on the western and northern shoreline (see Map 3a). Both streams are rated in City critical areas regulations as ephemeral and non-salmonid bearing. The northern tributary flows past a wetland just upstream of its mouth. The northern wetland and stream delta are a unique hemlock-forested peatland, a highly sensitive Category I wetland (Lower Cedar River #15 in the King County Wetland Inventory) that is one of few remaining in the urbanizing Puget Sound lowlands (King Co. 10993). (Table 4-19; see Map 1e). An area of hydric soil to the south of the Lake may be evidence of a historic wetland. Other wetlands may occur in the area that have not yet been identified or mapped.

4.6.2.2 Fish and Wildlife Presence

No priority habitats are found within the Lake Desire shoreline, nor is the Lake accessible to anadromous salmonids (see Map 5a). Lake Desire has historically been stocked with non-native rainbow trout, yellow perch, pumpkinseed sunfish and largemouth bass, which all still inhabit the Lake.

Lake Desire-Spring Lake Park serves as a wildlife corridor between the two lakes. Contiguous natural upland areas ring Lake Desire to the east, north, and west, but residential development along the lakeshore presents a barrier to wildlife movement to and from the lake.

4.6.2.3 Nearshore and Riparian Habitat

Areas of residential land-use along the east, north, and west shorelines have degraded riparian functions, but areas of mixed and deciduous forest are still present, interspersed with residential lots and in natural areas along the north and southeast shoreline. In particular, the stream corridor contains high-quality mixed and coniferous forest, although the lakeshore is rimmed by shrub and deciduous trees (see Maps 1e).

King County (2008) indicates medium-high ecological function for LWD quality along the entire shoreline. Aerial photography shows LWD and other organic debris along much of the shoreline, including in residential areas. LWD is also apparent along the south lakeshore, where parkland protects the riparian corridor from severe development impacts. The natural stream delta at the north end of the Lake has little organic debris due to low recruitment-potential of the shrub-dominated lakeshore.

Nearshore habitat is impacted seasonally by increased phosphorus loads that cause algal blooms. In addition, the invasive Eurasian milfoil has established itself in the Lake. Both conditions alter natural habitat conditions and limit access to important shallow-water habitat.

Shoreline Modifications

A review of aerial photography identified approximately 57 docks/piers. Thirty-eight of these are along the western shoreline and 19 along the eastern shoreline. No quantitative data are available for bank armoring, which is not discernible from aerial photographs. However, substantial areas of native shrub/forest communities are interspersed with landscaped areas with single family lots, suggesting that a majority of the shoreline remains unarmored, particularly along the east shoreline, where single-family lot density is lower and parkland abuts the shoreline.

4.6.2.4 Other Natural Features

No flood hazards, aquifer recharge areas, or seismic hazard areas are located within the Lake Desire shoreline. Steep slopes along the southeast lakeshore present both erosion and landslide hazards that would increase if the existing forest was lost (see Map 4a).

4.6.3 Built Environment

4.6.3.1 Existing and Planned Land-Use

Existing Land-Use

Land-use patterns along the shoreline of Lake Desire are a mix of low density residential (59 percent) and undeveloped lands (35 percent). Existing land-use was assessed using 2008 King County Assessor’s parcel data.

Planned Land-Use

The City’s Comprehensive Plan and zoning land-use designations in the Lake Desire shoreline planning area are low density residential (City of Renton 2008b).

Figure 4-12 shows the proportions of current land-use, zoning and comprehensive plan land-use designations for the Lake Desire shoreline. The data for city zoning and comprehensive plan land-use exclude roadways. Roads, categorized as transportation, are included in the existing land-use data.

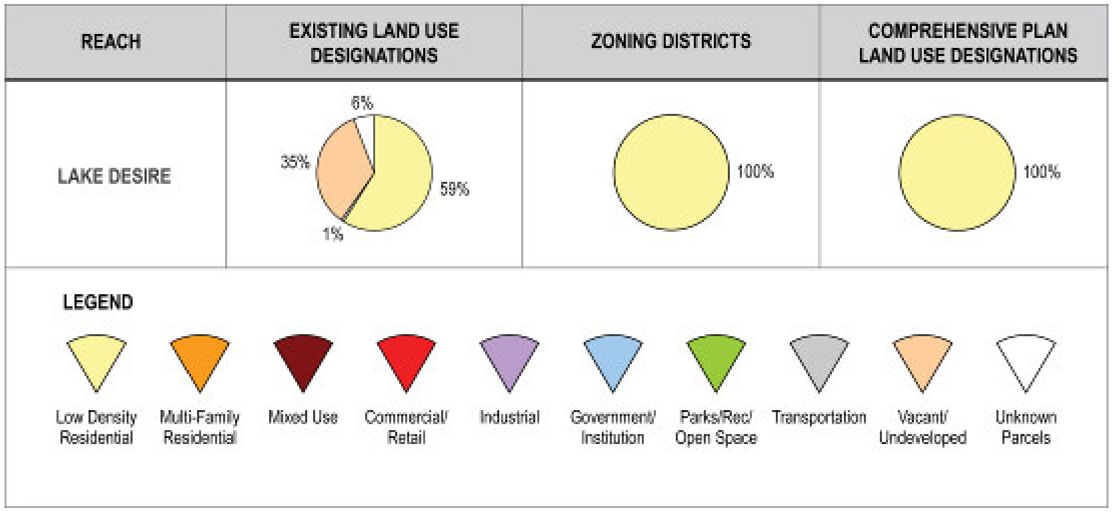

Figure 4-12 Percentages of Existing, Allowed and Planned Land Use by Reach in the Lake Desire Shoreline Planning Area

There are no water-dependent uses in the Lake Desire shoreline planning area. A review of King County Assessor's data revealed that there are no commercial or industrial properties along Lake Desire. Public access is provided at the north end of the Lake at the boat launch (see Section 4.6.2.3 – Public Access).

Vacant Lands

Table 4-20 provides the percentage of undeveloped parcels and undeveloped area. The undeveloped areas are designated for single family development.

Table 4-20. Existing Development of Waterfront Parcels along Lake Desire

Reach	# of Lots	% Undeveloped Lots	% Undeveloped Area
LD-A	139	38%	35%

Source: King County 2008; City of Renton 2008a

4.6.3.2 Impervious Areas

The City's impervious area GIS layer does not have impervious building areas for Lake Desire's shoreline planning area. Public ROW in the Lake is minimal (less than one acre). The predominant type of land-use in the Lake is single-family residential. Therefore, the impervious area due to buildings is expected to be similar to reaches in Lake Washington that have single-family uses (e.g., Reach K; City of Renton 2008).

4.6.3.3 Public Access

There is a WDFW boat launch at the north end of the Lake that is maintained by King County Parks and Recreation (Washington State Parks website 2008).

4.6.3.4 Infrastructure

Lake Desire Drive is located within the Lake Desire shoreline planning area. The City GIS database does not include utility information for Lake Desire (King County 2002).

4.6.3.5 Historic and Cultural Resources

Native American and Euro-American historic use of the Renton area is detailed in Section 4.1.4.5 (Historic and Cultural Resources – Lake Washington). A search of the DAHP database indicated that there are no state- or federally-registered sites and no inventoried sites within the Lake Desire shoreline planning area.

5. ECOLOGIC MANAGEMENT AND PROTECTION TOOLS

5.1 OVERVIEW

A wide range of options are available for management and protection of ecological functions in shorelines. The discussion below covers several topics including:

- Designation, rating and classification systems
- Functional assessment options
- Classification based buffers
- No harm regulations

5.2 DESIGNATION, RATING, AND CLASSIFICATION

There is no universally accepted method for classifying rivers, streams, and lakes or related habitat areas for regulatory purposes. In the State of Washington, there are a variety of classification systems used by different agencies based on specific regulatory needs. For example, Ecology classifies water types for the purposes of meeting water quality standards and employs a system that emphasizes the use of the water and the requirements of the Federal Clean Water Act, while DNR employs a system based on forest practices needs (Figure B1-3).

5.2.1 Washington DNR Stream Typing System

The DNR classification system was developed for forest practices and generally is based on the presence or absence of fish. The designation of shorelines of the state as a separate classification is based primarily on the statutory limitations on forest practices within shorelines of statewide significance in RCW 90.58.150 which allows only selective timber cutting. In general, the designation of streams over 20 csf as a separate category may be relevant because of the wider range of processes provided in streams with higher flows, but the DNR designation is not based on the presence or absence of particular geomorphic processes or ecological functions.

5.2.2 Fish Species and Lifestage Stream Classification System

The specific biological and ecological functions provided by individual streams differ substantially. Therefore, one potential classification system classifies stream reaches according to the fish species and lifestages present within the reach. The presence of salmonids in various life stages within a stream or river reach can indicate or infer information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would use the WDFW Priority Habitat Species (PHS) database to assign fish presence or life stage information. The database covers streams in the Renton UGA that have been identified as having anadromous species and classifies stream reaches as spawning, rearing, or migration habitat for each individual salmonid species. Other reaches of stream, where site-specific information is lacking, could be classified based on current knowledge as presumed or historical habitat for a species with the option that more detailed analysis could be done at the project review stage to confirm or change the presumption.

The primary advantages of this system are in its biological and ecological relevance, coupled with a relatively complete, easily accessible database. However, there are several potential drawbacks to such a classification system. First, the link between fish presence and the quality or type of aquatic habitat is not complete. Dams, for example, can completely block anadromous fish access to high-quality, productive, instream habitat, which may not be occupied for these reasons. Second, the quality of fish presence/life stage information is currently incomplete, and may be biased toward easily accessed valley-bottom reaches as compared to more isolated headwater tributary reaches.

In Renton, this option is not particularly valuable because most streams and lakes provide habitat for a variety of fish species, however specific reaches vary greatly in the character of the stream and adjacent uplands and the ecological functions provided.

5.2.3 Aquatic Habitat Quality Based Classification System

A third type of classification system is based on ecological functions using known differences in habitat quality and limiting factors to classify streams. The relative quality and quantity of individual geophysical or habitat parameters have direct correlation to the ecological functions that a particular stream reach or subbasin provides. The presence of particular species in various life stages within a stream or river reach can indicate or imply information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would rely on review of available reports on habitat conditions and limiting factors (e.g., LCFRB 2002) to assign a classification system based on the relative ecological condition of a stream reach or subbasin. The primary advantage of such a classification system is that ecological relevance is built into the system. However, several major disadvantages are also present. For example, detailed, high-quality information on habitat quality is not available for many stream and lake reaches within the Renton UGA, and because different sources of information have used different methods for habitat evaluation. Available information, therefore, is not directly comparable. Furthermore, in many cases this approach would require reliance on best professional judgment to combine information on multiple ecological functions in order to classify a particular stream or subbasin. Most likely, the approach would be most practical to apply at a larger spatial scale, such as the subbasin or subwatershed level, which could potentially negate the benefits by blending ecological function.

5.2.4 Functional Assessment Options

The current practice in assessing ecological functions provided by streams and other aquatic systems is to use a classification and rating system. Such systems focus on identifiable features and use rating systems to characterize factors such as sensitivity, significance, rarity, functions, and opportunities for replacement.

While the use of the current WDFW/DNR stream rating system is understood as common practice, it presents limitations that an ecosystem perspective can remedy. The current rating system focuses on discrete identifiable features of streams that are roughly related to functions important to aquatic species.

An alternative approach is to focus on the variety of functions provided by the landscape. The rationale for focusing on functions rather than the stream classification is to shift emphasis from a discrete element of the ecosystem, such as a stream, to a system of indicators that are integrated with other aquatic resource and habitat evaluations. Further, the current methodology relies on discrete stream evaluations. The alternative functional analysis would utilize structural components rather than particular features, such as streams, as the basis for units within sites. This also allows for a broader view of stream values that provides opportunities for including other functions, such as flood management functions, and evaluating water supply functions such as seeps and springs that have an integral part in aquatic ecological functions.

This functional approach allows for a detailed understanding of the ecosystem services provided by a natural or impacted site. Quantitative values can be developed for existing conditions in a natural or altered state, and alternatives can be compared in both restoration and impact scenarios. These values, or scores, allow for a clearer understanding of tradeoffs under site selection, design, or mitigation analysis.

The analysis of specific stream reaches in this report provides a qualitative assessment of these factors. It is not converted into a rating or other system because that intermediate step is not necessary in an area as small as the City. The approach used in the Draft SMP Policies and Regulations is to use all the relevant information about each reach in developing regulations that specify the application of the Shoreline Management Act's competing priorities for water dependent use, public access and preserving or enhancing ecological functions.

5.3 BUFFER OPTIONS

For protection of ecological functions in streams and lakes, wetlands and habitat areas, a relatively narrow range of options have been used in Washington State. Most of the regulations developed in Washington State have been related to Growth Management Act (GMA) requirements to protect Critical Areas.

The predominant means of regulating uplands adjacent to water bodies and areas adjacent to wetlands and critical wildlife habitat has been through buffers. The Shoreline Management Act makes reference to buffers in RCW 90.58(2)(f)(ii) which allows inclusion of buffers for critical areas in SMP jurisdiction

References to buffers in the Shoreline Master Program Guidelines (WAC 173-36) are numerous and include the following:

> WAC 173-26-186(2)(c)(i)(D) Buffers. Master programs shall contain requirements for buffer zones around wetlands. Buffer requirements shall be adequate to ensure

that wetland functions are protected and maintained in the long term. Requirements for buffer zone widths and management shall take into account the ecological functions of the wetland, the characteristics and setting of the buffer, the potential impacts associated with the adjacent land use, and other relevant factors.

WAC 173-26-186(2)(5)(b) Local governments may implement these objectives through a variety of measures, where consistent with Shoreline Management Act policy, including clearing and grading regulations, setback and buffer standards, critical area regulations, conditional use requirements for specific uses or areas, mitigation requirements, incentives and nonregulatory programs.

WAC 173-26-211(4)(f)(ii)(A) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.

WAC 173-241(3)(j) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.

A wide range of buffer widths have been analyzed for a variety of functions. Variation in recommendations or buffer effectiveness is frequently due to variation in site conditions such as side-slope angle, stream type, geology, climate, etc. Design of riparian buffers must consider the ecological, cultural, and economic values of the resource, land use characteristics, and existing riparian quality throughout watersheds in order to address the cumulative impacts on stream functions and the resources being protected (Johnson and Ryba 1992; Castelle et al. 1994; 2000; Wenger 1999).

Appropriate buffer sizes will depend on the area necessary to maintain the desired riparian or stream functions for the given suite of land-use activities. A wider buffer may be desired to protect streams from impacts resulting from high-intensity land use while narrower buffers may suffice in areas of low-intensity land use (May 2000). It should be noted though that opportunities for protection or improvement of buffer conditions in areas of high-intensity land use are often effectively foreclosed by existing development, or the existing habitat conditions are already highly altered. Under such conditions, establishing buffers wide enough to provide an effective full-range of riparian functions is likely unattainable; other actions may be required to improve habitat conditions beyond what riparian buffers are able to provide. In addition, buffer vegetation type, diversity, condition, and maturity are equally as important as buffer width, and the best approach to providing high-quality buffers is to strive for establishing and maintaining mature native vegetation communities (May 2000).

Potential riparian, lake wetland and habitat buffer frameworks include the following types, which are discussed in greater detail below:

1. **Standard Single-Zone Buffers** – Fixed-distance stream buffers based on the maintenance of individual aquatic functions. The buffer widths may be further divided by land use (e.g., urban versus rural) or by other variables.

2. **Dual-Zone Buffers** – This approach employs two smaller adjacent buffer zones, which, when combined, make up the overall riparian buffer. An inner "core" zone, directly adjacent to the aquatic feature, consisting of an area where uses are prohibited or severely restricted, and an outer riparian zone, adjacent to the core zone, where uses are still restricted, but to a lesser degree.
3. **Reach Based Buffers –** This approach is most relevant to streams and lakes that have been altered by human use. The approach focuses on "no net loss" of existing functions as they currently exist.

All of the above approaches could potentially incorporate buffer averaging techniques, in cases where the overall buffer area will be equal to un-averaged conditions, and it can be clearly demonstrated that averaging will result in no net loss of aquatic functions.

5.3.1.1 Standard Single-Zone Stream Buffers

Single-zone buffers are the most common type of riparian buffer, with a designated minimum buffer for each class or type of stream/habitat as defined by the applicable stream classification scheme.

The advantages of single-zone stream buffers are that they

- are the most common buffer type and have had extensive best available science (BAS) and legal review;
- are relatively simple to understand from a public standpoint and lend themselves to straightforward and efficient administrative processing; and
- allow for buffer averaging.

One disadvantage of such a system is that riparian buffers are not uniform in the functions they provide relative to the width of the buffer, as discussed further below.

Table 5-1 developed by Parametrix scientists summarizes this information in relation to the specific aquatic functions that are of greatest importance in maintaining conditions suitable to support fish and other aquatic life (e.g., LWD recruitment, stream temperature, sediment filtration). For each buffer width, the suitability of the buffer is rated by its ability to maintain these aquatic functions. Although this evaluation is qualitative, it is firmly based on BAS regarding ecological functions.

An example of a buffer recommendation based on a choice of a critical factor is the recommendation by Pollack and Kennard (1998) of a minimum buffer width of 250 feet on all perennial streams based on LWD recruitment and the height at maturity of trees in Pacific Northwest forests. These buffer widths of one SPTH would reasonably provide for a full range of riparian functions, and therefore, not contribute significantly to the loss of salmonid habitat. May (2000) and other extensive reviews provide detailed summaries of buffer width sizes necessary to achieve stream and riparian functions (Knutson and Naef 1997; FEMAT 1993).

As mentioned above, the disadvantage of uniform buffers is that a single buffer is designed to provide multiple functions. Depending on the stream and the adjacent use, some functions may continue to be provided on adjacent land outside of the buffer with appropriate management practices. For example, the riparian functions of bank stability and litter fall are primarily provided for within a relatively short distance of a waterbody (10 to 50 feet). Also, along highly managed streams such as in agricultural, residential, or commercial areas, some functions normally provided (at least in part) by riparian buffers, such as flow attenuation or filtration of pollutants, can be provided by application of appropriate BMPs in combination with smaller buffers. In addition, uniform buffers do not take into consideration the extent to which different vegetation communities in different parts of the buffer contribute to specific riparian functions. For example, impacts to the outer 25 feet of a 100-foot-wide buffer would likely have much less impact to bank stability and litter fall functions than would identically scaled impacts directly adjacent to the stream.

Table 5-1. Comparison of Functions of Stream and Lake Buffer Widths

	Buffer Width				
Stream Function	**15 Feet**	**50 Feet**	**150 Feet**	**300 Feet**	**600 Feet**
Microclimate	X	X	N	P	F
Wildlife Habitat	X	N	P	P	F
LWD Recruitment	X	N	P	F	F
Pollutant Removal	N	N	P	P	F
Sediment Filtration	X	N	P	F	F
Water Temperature	X	N	F	F	F
Organic Litter	X	P	F	F	F
Bank Stability	X	F	F	F	F

KEY
F = Buffer width fully supports/maintains stream function.
P = Buffer width partially supports/maintains stream function.
N = Buffer width nominally supports/maintains stream function.
X = Buffer does not adequately support/maintain stream function.

In an urban setting, the range of activities adjacent to a resource may affect the size or character of a buffer. Degradation of wildlife by domestic animals is difficult to address by buffer size, no matter how extensive. Buffers also may become habitat for feral domestic animals. In such a case, controls on domestic animals, such as fencing, may be needed in addition to buffers.

Buffer enhancement, particularly at the margins, protection from invasive species and other vegetation management is critical for effective buffers in areas dominated by human influence.

5.3.1.2 Dual-Zone Stream Buffers

This approach, commonly used in forestry applications, is similar to the single-zone stream buffer (see above). However, the overall stream buffer is composed of two smaller adjacent buffer zones, which when combined make up the overall riparian buffer. The two zones are:

- An inner "core" buffer zone, located directly adjacent to the aquatic feature. In this area land uses are prohibited or severely restricted.
- An outer riparian zone, landward and adjacent to the core zone, where land uses are still restricted, but to a lesser degree than within the core area.

Dual-zone buffers are not as common as single-zone buffers and are more complex from a public understanding and City administrative standpoint, although buffer averaging could still occur within the outer riparian zone.

The primary advantage of this type of buffer system is that the dual-zone system incorporates BAS indicating that riparian buffers are not uniform in the functions they provide relative to the width of the buffer. For example, for a relatively small stream that supports salmonid rearing and has a mixed forest riparian buffer, a continuous buffer width of 75 to 100 feet may be adequate to support the aquatic functions of LWD recruitment, temperature regulation, and the provision of detritus and nutrients to the stream. The segment of the buffer from 100 to 150 feet still supports important ecological functions such as pollutant filtration and microclimate regulation, but in this outer area a solid homogeneous buffer may not be required to support these functions to a high degree. In summary, as compared to a single-zone buffer, a dual-zone buffer may allow for different impact types within different parts of the buffer.

Examples of specific ecologically relevant provisions that could be applied to the outer buffer zone include:

- A limit to the amount of clearing allowed within the outer buffer zone.
- A minimum amount of forest required to be retained within the outer buffer zone.
- A limit to the amount of impervious surface allowed within the outer buffer zone.
- A limit to the development density allowed within the outer buffer zone.

In this system, the overall buffer width for the combined dual-zone buffers would be wider than for the single-zone buffer, because more uses are allowed within the outer portion of the dual-zone buffer. This approach has the advantage that it is adaptable to a wide range of land use activities, and gives the applicant choice on which approach is best suited to their particular situation, while still maintaining equal levels of aquatic habitat functions for the overall system. A disadvantage of the system is that it may be more difficult to administer, as compared to a single-zone buffer approach.

Dual zone systems are implicitly recognized in the 211(4)(c)(ii) in reference "parallel environments" that divide shorelands into different sections generally running parallel to the shoreline or along a physical feature such as a bluff or railroad right of way. Such environments may be useful, for example, to accommodate resource protection near the shoreline and existing development further from the shoreline.

5.3.1.3 Specific Stream or Lake Reach Buffers

An additional approach to stream buffers that combines some of the advantages of both the classification-based buffer system and a “no harm” approach are applying specific buffers for specific reaches based on assessment of the functions currently being provided by those reaches. This approach is particularly applicable to streams in areas of existing high-intensity land use where parcels are small and few remain undeveloped, and there is little practical opportunity to achieve buffers that will provide the full range of desired riparian functions.

In this case, the objective of the management approach is to preserve the existing functions and to improve, if possible, a limited range of functions such as improving temperature and water quality. Improving temperature through providing effective overhead shade can be achieved to varying degrees with intensive management of smaller buffers. Water quality improvements can be achieved by stormwater management and control of fertilizer and other chemical applications near streams.

5.3.2 "No Harm" Regulatory System

This type of regulatory system is best known in Washington State in its application to agricultural use in Skagit County. The approach was endorsed in challenges heard by the Growth Management Hearings Board for Western Washington and the Washington State Supreme Court (*Swinomish v Skagit 2006*). The "no harm" approach may be regarded as an "adaptive management" approach to protecting critical areas.

The most succinct overview of a no-harm system is provided in a Growth Management Hearings Board decision. Although not directly related to Shoreline Master Programs developed under RCW 90.58, the rationale can be considered applicable.

> "After careful consideration of all the arguments, and the entire record, we are no longer convinced that the Act requires the County to mandate that regulation of critical areas provide for all the functions in every watercourse that contains or contributes to watercourses that contain anadromous fish in ongoing commercially significant agricultural lands where some of those functions have been missing for many years and where these functions are not required for a particular life stage of anadromous fish. By reaching the above conclusion, we are not saying that farmers do not need to alter their practices if they are continuing activities which will further degrade the streams. Those activities must stop and practices must be implemented which ensure no additional harm or further loss of function (*Swinomish Indian Tribal Community et al. v. Skagit County; 02-2-0012c).*"

Essential elements for such a program are adequate monitoring, benchmarks, and the ability to require changes to the program if benchmarks are not achieved. In assessing the difference between a prescriptive approach such as buffers and a "no harm" approach, both the hearings board and the court have held that local governments must either be certain that their critical areas regulations will prevent harm, or be prepared to recognize and respond effectively to any unforeseen harm that arises.

Implementation of a "no harm" approach in Renton is not likely to be effective in regulating future development. Application to urban development is substantially different than application to agriculture where changes in farming practices may be developed. It would be difficult to meet a "no harm" standard if monitoring of a specific buffer area determined that a functional criterion was not being met. If, for example, a particular buffer dimension was not effective, the presence of physical improvements such as roads or buildings would generally preclude its expansion. In addition, developing performance standards, implementing a monitoring system, and taking action to correct deficiencies would be very resource demanding both for property owners and the City. To be practical, additional areas would likely need to be reserved from development or land alteration to provide the opportunity for future change as well as requiring substantial security deposits for monitoring and reporting and corrective measures.

A "no harm" system also is likely to be much more difficult and expensive to implement, especially the monitoring component, and provides little certainty to applicants of the standards likely to be imposed on their development. It also introduces an element of uncertainty to land owners in the continued use of facilities initially allowed, but subject to adaptive management requirements.

6. FUNCTIONAL ANALYSIS AND OPPORTUNITY AREAS

Watershed-scale processes that have been altered by land-use degrade ecological function in shorelines. This section summarizes the conditions within each shoreline and assesses the potential for restoring ecosystem processes and improving shoreline ecological function (see Table 5-1).

The City lies very low in all watersheds containing shorelines and is highly urbanized. Combined with degraded ecological function, extensive development (expressed by lack of forest cover and large impervious areas) generally limits the potential for the City to implement projects within the City limits to restore processes at the watershed-scale.

Exploring other avenues to enhance ecological function within the shoreline, the City could:

1. Pursue restoration opportunities as properties redevelop along the shoreline.
2. Partner with others in WRIAs 8 & 9 to implement salmon recovery actions that were identified within the City. There is an urgent need to restore gently sloping beach area with native vegetation along Lake Washington shoreline for juvenile Chinook salmon and to remove or modify docks in water structures to reduce predation on juvenile Chinook. The City could also adopt stringent stormwater standards and rules that implement LID to reduce stormwater quality/quantity that routes to rivers and streams and adversely affects shoreline functions discussed in Section 3.
3. Encourage water conservation and the use of native plants in all landscaping applications to reduce water use.
4. Aggressively control invasive plants on all City-owned properties in the shorelines and other areas and work with adjacent property to control these species on their properties to reduce spread.
5. Work with King County to obtain a reduction in property tax for property owners that voluntarily improve their shoreline (not required as mitigation) to improve shoreline functions. There are technical resources available to help property owners make improvements to their shorelines that would improve functions.
6. Launch a database that includes the number/type/location of shoreline restoration actions and degradation actions within the City to determine if shoreline functions are improving over time.

In addition, the City can implement projects outside the City limits either individually or jointly with other government agencies. The City can also implement projects and/or management actions within jurisdictional shoreline focused on enhancing specific functions similar to the wetland mitigation bank in the Springbrook Creek shoreline (Section 4.5.2.1).

Generally, restoration actions should be prioritized where multiple processes can be enhanced. Floodplain areas in large river systems are a high priority because they are important areas for all processes, including water movement, materials storage, and shoreline-scale processes such as LWD recruitment and temperature regulation. Restoring wetlands in floodplains augments the potential effect of restoration.

Riparian and floodplain areas in tributaries are also priority areas, particularly where geologic deposits augment process function. Failing restoration and protection of these areas, enhancement of single processes that may be limiting ecological function becomes the priority.

The following sections describe specific conditions and opportunities within each shoreline.

Table 6-1. Influence of Watershed-scale Processes on Shoreline Ecological Function

Process	Major Alterations	Physical Functions											Biological Functions				
		Peak Flow	Baseflow	Hyporheic Exchange	Substrate Condition	Instream Habitat Simplification	Offchannel Habitat	Pool habitat	LWD Density	WQ Impairment	Temperature/DO	Terrestrial Habitat	Salmon Migration	Salmon Spawning	Salmon Rearing	Macroinvertebrates	Terrestrial Wildlife
Hydrology: Surface Runoff	Forest cover loss; impervious surfaces, channelization and hydromodification	●	●		●	●		●					●	●	●	●	
Hydrology: Storage	Wetland and floodplain loss	●		●			●								●		
Hydrology: Recharge	Forest cover loss; impervious surfaces		●				●				●						
Hydrology: Groundwater Movement	Wetland and floodplain loss, artificial drainage features, roads/embankments; withdrawals		●	●						●			●	●			
Sediment Input and Storage	Disturbed areas, channel instability (peak flows), wetland and floodplain loss, channelization, hydromodification			●	●			●		●				●	●		
WQ: Inputs and Storage	All land-use types; wetland and floodplain loss, riparian disturbance									●	●		●	●	●	●	

Table 6-1. Influence of Watershed-scale Processes on Shoreline Ecological Function (continued)

Process	Major Alterations	Physical Functions											Biological Functions				
		Peak Flow	Baseflow	Hyporheic Exchange	Substrate Condition	Instream Habitat Simplification	Offchannel Habitat	Pool habitat	LWD Density	WQ Impairment	Temperature/DO	Terrestrial Habitat	Salmon Migration	Salmon Spawning	Salmon Rearing	Macroinvertebrates	Terrestrial Wildlife
Temperature	Baseflow alteration, riparian disturbance												●		●		
Riparian/Organic Matter	Riparian disturbance, channel dredging and hydromodification	●			●		●	●	●	●	●	●			●		●
Biotic Interactions	Invasive species introduction; physical habitat alteration												●		●	●	●

6.1 LAKE WASHINGTON

Ecological function in lakes is facilitated primarily by water quality alterations in tributary basins and water quality and physical alterations along the lakeshore (Table 5-2). Most Lake Washington tributaries are highly developed, limiting restoration potential (Kerwin 2001). May Creek and the Cedar River are the least-developed basins draining to Lake Washington and also support a high degree of watershed function (Kerwin 2001). These watersheds have the greatest potential for management actions to protect and restore ecological function in the lake (see Sections 3.2.4.2-3 for analysis of May Creek and Cedar River).

6.1.1 WRIA Plans

The WRIA 8 Chinook Recovery Plan modeled the degree of land-use impacts and the importance for Chinook productivity along the Lake Washington shoreline. The report concluded that the City and its PAAs have the highest potential for restoration (King County DNR 2005). However, due to the level of development along the lake-shore, the number of potential restoration actions may be limited. Ecological function can be enhanced along the shoreline in public areas such as Gene Coulon Park and in redeveloping areas as evidenced by the Seattle Seahawks training facility and the Barbee Mill redevelopment. Site-scale, incentive-based actions supplemented by community outreach and education can also be an effective tool for voluntary restoration. These include riparian enhancement, bank softening, and removal/re-engineering of overwater structures. These actions would all improve nearshore habitat and potentially add important shallow water habitat given the right site conditions.

Table 6-2. Summary of Process Alterations and Management Potential, Lake Washington Shoreline

Process	Scale	Alterations	Restoration Potential
Hydrology: Flow Regime	Watershed	High Regional management of water resources has altered watershed hydrography and temporal water level fluctuations	Low Human needs expressed in existing land-use and water resource management limits potential for restoration of hydrologic processes.
	City	Not applicable	Not applicable
Water Quality: Inputs	Watershed	High Urbanized land-uses contribute toxins and nutrients from lakeshore and tributaries Point-source inputs from industrial sources	Low Lake Washington tributaries outside of the City are the most urbanized in the state, limiting the potential for effective protection and restoration.
	City	High Although the upper Cedar and May Creek watersheds are rural, areas within the city are still highly urbanized. The lakeshore is completely built-out.	Moderate May Creek and Cedar River basins are less urbanized than other Lake Washington tributaries and have potential for protection through Best Management Practices (BMPs) along the lakeshore must focus on limiting continuing degradation from existing development
Water Quality: Storage	Watershed	High Disturbed riparian corridors in low-order streams and loss of wetlands and floodplain connectivity	Low-Moderate Potential for wetland and floodplain restoration is low, but riparian restoration/protection to attenuate nutrient cycling through biotic uptake and improved hyporheic function is more feasible.
	City	High Remnant wetlands persist or have been restored along the lakeshore; floodplain connection is very minimal along the Cedar River; May Creek and other low-order tributaries have some riparian function	Low Lakeshore naturalization would improve groundwater exchange and potentially increase water quality in nearshore areas See Sections 5.2 and 5.3 for management options in May Creek and Cedar River

Table 6-2. Summary of Process Alterations and Management Potential, Lake Washington Shoreline (continued)

Process	Scale	Alterations	Restoration Potential
Sediment Quality: Inputs	Watershed	High Hydromodification limits sediment cycling along lakeshore; increased stormflow in tributary and disturbed land contributes increased fine sediment from tributaries	Moderate Naturalization of lakeshore is possible for re-development and incentive-based management; potential for managing tributary inputs is more limited
	City	High Hydromodification limits sediment cycling along lakeshore; increased stormflow in tributary and disturbed land contributes increased fine sediment from tributaries	Low-Moderate Restoration of shoreline banks is possible for re-development and incentive-based management; potential for managing tributary inputs is more limited
Organic Matter	Watershed	High Riparian disturbance along tributaries and lakeshore limits LWD contribution; loss of vegetated lakeshore limits natural cover preferred by native fish	Low-Moderate Restoration of lakeshore riparian vegetation is possible for re-development and incentive-based management; potential for managing tributary inputs is more limited
	City	High Riparian disturbance along tributaries and lakeshore limits LWD contribution; loss of vegetated lakeshore limits natural cover preferred by native fish	Low Local areas of forested shoreline are almost non-existent within the City. Management must be conducted primarily through re-development and incentives.
Biotic Interactions	Watershed City	High Introduced aquatic flora and fish species affect community dynamics through habitat alteration and predator-prey relationships. Hydromodifications typically increase invasive species productivity to the detriment of native species	Moderate Existing faunal interactions are difficult to manage but watershed-scale policies aimed at habitat-based management are possible at the site-scale, including removal of invasive species and preferential habitat restoration aimed at native species.

6.1.2 Ecological Productivity: Opportunities and Constraints by Reach

6.1.2.1 Lake Washington Reach A

Reach A lies between the Bellevue city limits and Renton city limits. It is entirely single-family residential use, where bulkheads and docks predominate. Natural riparian vegetation has been removed, and only a few residences have trees or shrubs that support natural habitat functions. However, many of the bulkheads do not extend far into the lake, leaving a small amount of shallow water habitat used by Chinook and other shallow water fishes. Most of the docks in these reaches are narrow at the shorelines; therefore, most are not likely to impede shoreline migration of young Chinook.

Opportunities for maintaining and enhancing ecological productivity include:

- Restoring shallow water habitat to facilitate young salmon rearing and to include: shallower shoreline depths and slope, greater substrate composition mix, and alteration or replacement of bulkheads, to (a) sloped with shallow depths, or (b) composed of logs or riprap, and (c) excluding concrete, riprap, or sheet pile exposed below the OHWM (which eliminates the shallow water habitat).
- Replanting native shoreline vegetation overhanging at the shoreline edge to provide shading, refuge habitat and enhanced prey resources (insects) for young salmon and other fish, isolation of grass areas from the shoreline, and reduction of need for fertilizers and pesticides.
- Limiting the total number of docks, the number of docks in shallow water (0-3 feet), and the number and size of piles supporting over-water structures.
- Upgrading to grated docks (or other means) to reduce potential predation and facilitate shoreline migration of young salmon.
- Augmenting density of woody debris at the shoreline and embedding it, to provide refuge habitat for young salmon and reduce habitat for smallmouth bass (*Micropterus dolomieu*) prey.

Many of these may be required by USACE at the time of construction or replacement of docks and bulkheads.

Constraints relate largely to the existing developed character of the shoreline and the lack of necessity for bulkhead or dock replacement in most cases. Bulkheads made of durable materials in this area are unlikely to fail and require replacement. Docks tend to have a practical lifespan of about 20 years. Given this situation, it is unlikely that a substantial portion of the shoreline would be upgraded over a 15- to 20-year period.

A regulatory approach that tied replacement of docks and bulkheads to major remodeling or replacement of residences would provide additional opportunities to require upgrading docks, bulkheads, and riparian vegetation. Under this approach, bulkheads, docks, and vegetative cover not meeting current standards would be considered non-conforming. Thresholds of percent of floor area or value added to a residence would trigger compliance with new standards for the shoreline.

Regulations can also encourage this type of installation by:

- Allowing fill below the OHWM for shoreline protection and habitat enhancement

- Allowing regrading of existing shorelines without penalizing landowners if the OHWM is moved back by allowing setbacks to be measured from the previous bulkhead line

This is an area and a type of use where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation. Such programs are most likely to lead to changes in management of riparian vegetation. However, it is unlikely that voluntary programs will lead to a result in changes in bulkheads and docks, unless they are failing or need replacement for other reasons.

6.1.2.2 Lake Washington Reach B

Reach B extends from the Renton city limits to the Seahawks Football Training Facility and includes mostly single-family use with one large shoreline multi-family development. The character is similar to Reach A and involves similar opportunities, constraints, and regulatory options.

6.1.2.3 Lake Washington Reach C

Reach C extends from the recently constructed Seattle Seahawks headquarters and training facility at the northernmost portion to the former Barbee Mill site at the southernmost portion of the reach. The Quendall Terminals south of the Seahawks headquarters has been designated a Superfund site by the U.S. Environmental Protection Agency (EPA). The site is being studied by the EPA to determine the extent of the pollution caused by coal tar and creosote application and the best course of action to clean it up. A residential development is currently being built on the former Barbee Mill site.

The shoreline adjacent to the Seattle Seahawks facilities have undergone recent regrading and replanting in some areas, with retention of existing deteriorating wooden bulkheads in others. Some overhanging vegetation and deciduous tree cover does exist, but existing riparian areas generally have sparse vegetation.

The shoreline of the Quendall Terminals site retains substantial native vegetation in the riparian zone mixed with a variety of deteriorating bulkheads and other structures along the shoreline and in the water. At this time, it is unknown whether potential cleanup of the Superfund site will extend to the shoreline areas.

The former Barbee Mill site has had extensive shoreline restoration along the western half of the site where bulkheads were removed and the shoreline regraded to depend on the beach grade and shoreline logs to provide shoreline protection. The area is required to be revegetated, but full installation has not occurred to date. Planting plans include largely shrubs with vine maple being the only tree. This will provide some benefits of native riparian vegetation but will not provide the shading benefits of larger native trees for temperature attenuation of the nearshore. The eastern portion of the shoreline is largely sheet pile bulkheads retained from the former sawmill operation and riprap.

Opportunities for maintaining and enhancing ecological productivity relate to extensive shallow habitat that is very productive for a variety of species. Existing and potential actions include:

- Enhancement of shorelines through bulkhead removal and riparian plantings that have been partially realized by restoration activities of adjacent uplands at the Seahawks training facility and Barbee Mill subdivision. All of the items listed above in Lake Shoreline physical attributes related to Chinook have been, or may be applied to this reach.

- The delta of May Creek has the potential to provide extensive enhanced shallow habitat if the natural process of deposition is allowed to continue. The delta was formerly dredged periodically to accommodate log storage for the previous use as a sawmill. A high priority for a productive nearshore should be allowing the natural processes of delta formation to occur. The delta likely will extend to the south and west over a substantial area during the next 20 to 40 years. This will result in shallow habitat in areas dredged in the past, including adjacent to bulkheaded areas of the Barbee Mill subdivision, as well as adjacent to residences to the south. This natural deposition process will likely result in very productive shallow habitat areas and a complex of wetland and upland areas.
- The productivity of the May Creek delta can be enhanced by speeding the natural process of creating upland areas within the wetland with riparian vegetation. This could be accommodated by (a) placing fill in the area once the natural delta processes have produced shallow enough conditions to allow this to be practical and (b) planting with upland riparian vegetation.

The WRIA 8 Salmon Recovery Plan Project C280 calls for the restoration of the mouth of May Creek.

Constraints relate to:

- Existing moorage in the area that will be rendered less useful with shallower water due to delta formation. There is one former boathouse previously used by the sawmill and a joint-use dock in the area. Limits due to shallow water could be addressed by (a) extending docks into deeper water, (b) relocating further from the delta, or (c) transitioning to use of mooring buoys in deeper waters. In that case, docks would be used by small boats that provide access to mooring buoys. Access to the former sawmill boathouse will be problematic with increased delta deposition. This facility may be considered non-conforming as to its original purpose related to the sawmill and may be considered ineligible for maintenance dredging for access with the cessation of sawmill use.
- In the long term, delta formation will result in deposition within public aquatic lands that eventually will provide upland areas having a variety of riparian vegetation. This vegetation may obstruct open water views from upland residences.

6.1.2.4 Lake Washington Reach D

Reach D extends from May Creek to Mountain View Avenue. This is a single-family area on lots that are of limited depth, often less than 100 feet. Access to most lots is from a private road on the BNSF (now Port of Seattle) railroad right-of-way. Many of the lots are within a 1904 subdivision of Lake Washington bottomlands. These lots are very constrained and have limited setbacks from the shoreline. The shoreline consists almost entirely of bulkheads of large riprap or concrete. Most residences have docks that are very close together. There is shallow nearshore habitat in the area, but the density of docks may impede shoreline migration of young Chinook or force them to migrate to deeper water away from food sources. The City's Kennydale Park is in this area and includes concrete bulkheads and playground and lawn areas. The park is devoid of native vegetation.

Opportunities for maintaining and enhancing ecological productivity include all of the items listed above for Reach A designed to provide a more productive nearshore environment. Many of these may be required by USACE at the time of construction or replacement of docks and bulkheads. South of North 34th Street, there is a small area of the shoreline that is part of the railroad right-of-way, now owned by the Port of Seattle, that is relatively natural. The parcels to the south are also larger. As discussed under Reach A, SMP regulations can lead to a gradual upgrade of bulkheads, docks, and adjacent vegetation to reduce impacts on aquatic habitat. This is an area where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

Constraints relate largely to the existing high intensity of development on this reach. The placement of residences close together and close to the water provides limited opportunities to reduce dock coverage or provide an area of native vegetation adjacent to the shoreline. In addition, the infrequent need to replace bulkheads and docks are not likely to lead to much upgrading. The Kennydale Park theoretically could provide opportunities for ecological restoration, but at the expense of active recreation and public access, which is also an SMA goal.

6.1.2.5 Lake Washington Reach E

Reach E extends from Mountain View Avenue to Gene Coulon Park. It is entirely single-family residential but has greater depth and width than most residential shoreline in Renton, with greater setbacks of buildings from the shoreline. There is also more vegetation along the shoreline, although most is ornamental. The shallow nearshore habitat is used by Chinook and other shallow water fishes. The greater separation between docks and the generally small size of docks in the area are not likely to impede shoreline migration of young Chinook.

Opportunities for maintaining and enhancing ecological productivity include all of the items listed above for Reach A that has a similar character of development. Many of these may be required by USACE at the time of construction or replacement of docks and bulkheads.

Constraints relate largely to the existing developed character of the shoreline. The infrequent need to replace bulkheads and docks is not likely to lead to a significant number of replacements in the short term.

This is an area where a regulatory approach that tied replacement of docks and bulkheads to major remodeling or replacement of residences would provide additional opportunities to require upgrading docks and bulkheads as outlined under Reach A. Many of the residences in this area, however, have been replaced or extensively remodeled in the past decade. Regulations can lead to a gradual upgrade of bulkheads, docks and adjacent vegetation to reduce impacts on aquatic habitat. Education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

6.1.2.6 Lake Washington Reaches F and G (Gene Coulon Park)

Reach F is the less developed northerly portion of the park and provides generally favorable physical shoreline characteristics with productive shallow nearshore habitat. However, native vegetation in the riparian zone is variable. From the north park boundary to near Kennydale Creek, vegetation consists of lawn with a narrow fringe of grasses, forbs, and bushes near the shoreline that consists of a deteriorating wooden bulkhead. In the vicinity of John's Creek, there is an area with native evergreen and deciduous vegetation, as well as several other small areas of largely cottonwood trees. The shoreline from John's Creek to the aquatics center at the north extent of the parking area is cobble beach. There is a riprap section of shoreline near the aquatics center, but most of the shoreline to the south is gravel beach.

Opportunities for maintaining and enhancing ecological productivity in Reach F relate largely to the addition of more riparian vegetation with overhanging brush that would improve shoreline refuge habitat for young salmon. Additional riparian buffer vegetation would enhance prey resources (insects) for young salmon and other fish, as well as isolate grass areas from the shoreline. Limiting public access (dogs, kids, and adults) to specific areas would limit the disruption of young salmon rearing in shallow water, and avoid impacts to the riparian vegetation.

See Reach G for discussion of Constraints.

Reach G is the more developed southerly portion of the park that includes activity areas, restaurant uses, a large launch ramp and parking area, and the intensively used beach area. The shoreline in this area is largely gravel beach, except where armoring has been added to protect walkways and other features and the concrete bulkhead between the restaurants and the launch area. Vegetation is primarily lawn. John's Creek enters the park between the launch ramp and the swimming beach and provides shallow habitat and replenishment of the beach.

Juvenile Chinook use throughout the park is very high. The gently sloping sand-gravel beaches, including the swimming beach, provides shallow water habitat used extensively by juvenile Chinook soon after they enter Lake Washington from the Cedar River. Surveys of juvenile salmon use in the area have extended over several years. The peninsula, at the south end of Gene Coulon Park, provides natural riparian vegetation overhanging the natural shoreline (Tabor 2003; Tabor et al. 2006).

Opportunities for maintaining and enhancing ecological productivity in Reach G also relate to addition of more riparian vegetation with overhanging brush that would improve shoreline refuge habitat for young salmon; however, because of the more developed character of the reach, the opportunities are fewer.

The WRIA 8 Salmon Recovery Plan Project C268 calls for enhancement of the mouth and lower portion of John's Creek. The project would enhance the mouth, remove silt, facilitate recruitment of sand and gravel, and protect shallow water habitat. Project C267 calls for enhancement of the mouth and Lower John's Creek channel to reduce predator habitat, restore riparian vegetation, and protect water quality and quantity from stormwater flows. The project would enhance the mouth, remove silt, and facilitate recruitment of sand and gravel.

Constraints for Reaches F and G relate largely to the design goals of the park in providing areas for picnicking and other active uses, as well as visual access to the shoreline. Additional native trees could be provided in areas of the shoreline that would continue to allow substantial lawn areas and allow framed views of the water from upland portions of the park.

6.1.2.7 Lake Washington Reach H

Reach H is the location of Southport mixed-use development. Long-term plans for the site include 338 apartments, 40,000 square feet of commercial/retail/restaurant use, 789,000 square feet of office use, and a luxury waterfront hotel (SECO 2008). About one-third of the 600-foot frontage is currently developed as a multi-family use; the remaining area is vacant. The entire shoreline consists of a concrete walkway adjacent to the shoreline, which incorporates portions of a previous wood bulkhead and pier built originally for the Shuffleton Steam Plant. A sheet-pile channel for steam plant cooling water extends into the lake.

Opportunities for maintaining and enhancing ecological productivity relate largely to (a) preserving the movement of salmon fry and other aquatic species across the shoreline and (b) mitigating impacts of development, including water quality and disturbance from high levels of human use. Potential options include maintaining and restoring shallow habitat and the potential addition of riparian vegetation with overhanging brush. Non-water-oriented uses, such as the retail/restaurant uses contemplated, require provision of public access and/or ecological restoration to comply with WAC 173-26-26-241(3)(d). This has been accomplished in areas with extensive public walkways, as indicated in the photo below.

Thea Foss bulkhead

City of Tacoma

Constraints relate largely to the design goals of the mixed-use development proposed for the site. Incorporating a more ecologically productive waterfront for nearshore habitat may limit some development options, but can be incorporated with appropriate design. Opportunities also may be limited by the terms of current permits (which have an expiration period).

6.1.2.8 Lake Washington Reach I

Reach I is the shoreline frontage of the Renton Boeing Plant immediately east of the mouth of Cedar River. About half of the frontage is public aquatic lands. The public land frontage of 1,200 feet is about half isolated from the water by the power plant outfall and has about 600 feet of gravel and sand beach. Vegetation cover is largely shrubs and small willows. The beach section of the waterfront has productive shallow nearshore habitat. The section adjacent to the power plant outfall is deeper and has little habitat value at present. The Boeing Company has an easement for wing overhang over the public lands. The City of Renton has proposed the Sam Chastain Waterfront Trail, which would connect the public access at the Southport development to the Cedar River Trail. The Renton pier is located at the western edge of this reach. The Boeing Plant shoreline west of the aquatic lands consists of concrete bulkhead or riprap and is largely devoid of vegetation, although bounded by shallow nearshore habitat.

A portion of this reach consists of the Cedar River delta that provides a large amount of natural shallow water habitat at the mouth of the river. In the past, the Cedar River delta was periodically dredged. Renton has no plans to dredge the delta in the future for flood control. The delta has not yet developed any areas of sufficient elevation to support riparian vegetation but does provide a large amount of shallow water habitat where young Chinook first enter the lake. Habitat at the river's mouth is particularly important because it is the first low velocity rearing habitat encountered by salmon fry after they pass through the rapid velocity migratory corridor of the lower Cedar River. As demonstrated by Tabor et al. (2006), the use of shallow shoreline habitat by young Chinook is greatest with proximity to the Cedar River mouth.

Opportunities for maintaining and enhancing ecological productivity include:

- Maintaining and enhancing the productivity of the delta of the Cedar River. This can be done by allowing the natural process of deposition to continue, which will lead to continuing shallow habitat and eventual formation of uplands that will support riparian vegetation.
- Hastening the natural process of the formation of delta islands by adding material to the delta to raise the surface to elevations that will support native riparian vegetation. This will allow opportunities for habitat improvement. Most of these opportunities are in public aquatic lands. Large woody debris (LWD) may be installed in this area if deeply embedded to stabilize shorelines. LWD can provide habitat for prickly sculpins, which are substantial predators of young salmon (Tabor et al. 1998).
- Enhancing shorelines through riparian plantings on the aquatic shorelines that are natural beach areas, which would enhance the nearshore aquatic habitat.
- Removing the existing sheet pile outfall, or placing fill outside of the sheet pile wall with the potential to extend the area of shallow nearshore habitat.
- Redeveloping or replacing the Boeing Plant shoreline in the future would provide opportunities to provide a full range of restoration along this 1,100-foot-long shoreline.

The WRIA 8 Salmon Recovery Plan Project C269 calls for restoration of public aquatic lands as part of the Sam Chisham Trail, including removing a portion of flume to create shallow water habitat, protecting the existing cove, and planting overhanging riparian vegetation along the shore.

Constraints relate largely to funding opportunities for enhancement. The Boeing Plant is not likely to substantially change while airplane manufacturing continues. Any enhancement activities are likely to be related to public projects like the Sam Chastain Waterfront Trail, which is proposed along this reach, or through public funding for salmon enhancement. The public aquatic lands that are about half the shoreline frontage provide an opportunity for management of aquatic habitat that would connect the public access at the Southport development to the Cedar River Trail. If the Boeing Plant should be redeveloped in the future, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

6.1.2.9 Lake Washington Reach J

Reach J is the shoreline frontage of the Renton Municipal Airport. Use as a seaplane base and runway end requirements have led to management of riparian vegetation. Low-growing forms have been used or no vegetation permitted to prevent birds from becoming a hazard to aviation. There is some woody debris in the water near the end of the runway that enhances shoreline habitat. The airport currently has concrete and rock riprap from the Cedar River to the seaplane ramp and a vertical sheet pile bulkhead west of the seaplane ramp.

Relocation of the seaplane dock to deeper water with associated dredging is proposed to maintain seaplane access to that facility. A section of the shoreline dock is proposed for relocation to an offshore position eliminating cover over a shallow water portion of the shoreline.

Opportunities for maintaining and enhancing ecological productivity include many of the same measures applied for Reach H to the east including:

- Maintaining and enhancing the productivity of the delta of the Cedar River.
- Providing habitat improvement opportunities by hastening the natural process of formation of delta islands that will support native riparian vegetation. Aviation safety will limit opportunities in the immediate vicinity of the runway.
- Enhancing shorelines through placement of fill adjacent to the bulkheads, which would provide for riparian plantings that will enhance the nearshore aquatic habitat.
- Acknowledging that future redevelopment or replacement of the Boeing Plant may affect the viability of the airport. Redevelopment would provide opportunities for a full range of restoration along this 850-foot-long Lake Washington shoreline, as well as about a mile of Cedar River shoreline.
- Placing substrate against the sheet pile to provide a narrow bench for low-growing riparian vegetation.

Constraints relate largely to potential conflicts with the operation of the municipal airport and funding opportunities for enhancement. The establishment of riparian vegetation in the area has the potential of attracting increased populations of birds that are a potential hazard to aviation. In addition, the airport is not likely to substantially change while the Boeing Plant on the east side of the Cedar River is in operation. Some mitigation to aquatic habitat is currently being developed as mitigation for alterations to the existing seaplane dock on the shoreline. Other enhancement activities are likely to be publicly-funded for salmon enhancement. If the airport should be redeveloped in the future, in conjunction with redevelopment of the Boeing Plant, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

6.1.2.10 Lake Washington Reach K

Reach K extends from the Renton Municipal Airport to the Seattle city limits and is largely a PAA of the City of Renton. This area is similar in character to Reaches A and D and consists of relatively small lots with limited depth and shoreline frontage largely bulkheaded. Lawn and ornamental vegetation predominates. Much of the water surface is covered by docks and moored vessels. Many bulkheads in this reach extend to water depths of several feet at the low lake elevation and there is limited shallow shoreline habitat. There are two privately-owned undeveloped parcels in this reach with a total of about 250 linear feet of unarmored shoreline. Existing development that has caused these conditions continues to degrade conditions through ongoing landscaping practices and shoreline modification, including installation of bank features and new overwater structures.

Opportunities for maintaining and enhancing ecological productivity include all of the items listed above for Reach A that has a similar character of development. Many of these may be required by USACE at the time of construction or replacement of the docks and bulkheads. SMP regulations can lead to a gradual upgrade of bulkheads, docks, and adjacent vegetation to reduce impacts on aquatic habitat. These regulations can (a) designate bulkheads and docks not meeting current standards as non-conforming, (b) allow fill below the OHWM for shoreline protection and habitat enhancement, and (c) allow regrading of existing shorelines without penalizing landowners if the OHWM is moved back by measuring setbacks from the previous bulkhead line.

Constraints relate largely to the existing high intensity of development on this reach. The placement of residences close together and close to the water provides limited opportunities to reduce dock coverage or provide an area of native vegetation adjacent to the shoreline. In addition, the infrequent need to replace bulkheads and docks is likely to lead to a slow pace of upgrading. This is a case where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

6.2 MAY CREEK

6.2.1 Overview

The upstream portions of the May Creek watershed lying within a number of tributaries in Renton and Newcastle are highly urbanized. These upstream conditions, relating largely to impervious surfaces and associated urban runoff, have altered hydrologic conditions that lead to increased sediment inputs from erosion and scouring into tributary channels and, to a lesser extent, May Creek. Upstream urban development also increases pollutant and nutrient loads to the stream. Increased sediment inputs and impaired gravel quality are a major concern because lower May Creek is an area of intensive salmonid spawning activity.

The dominant process mechanism in May Creek is water storage (City of Renton 2001). Protection and restoration of floodplains, depressional wetlands, and riparian forest cover have the greatest potential for improving shoreline ecological function.

Areas located outside the UGA have a greater potential for protection and restoration because they have a rural character. The May Valley floodplain is extremely important for all processes, and restoration of the riparian corridor and associated wetlands will have the greatest impact of process and ecological function.

In addition, planning in the upper watershed that protects existing sensitive areas (e.g., aquifer recharge zones) and establishes thresholds for impervious area and forest cover can prevent further increases in stormflow, sediment inputs, and water quality degradation.

The portions of May Creek within the City have largely intact vegetated riparian corridors, with the exception of short reaches with adjacent residential development and Reach A, which was previously re-routed. Reach A is currently being revegetated as part of the adjacent residential development. However, the 35-foot-wide buffer provides limited habitat functions, and it will be many years before vegetation reaches a size sufficient to provide substantial shade and temperature attenuation. The City of Renton Trails and Bicycle Master Plan includes a goal to provide a buffer and soft surface trail corridor from Lake Washington to Cougar Mountain

Within the shoreline, potential also exists for functional enhancement. The existing floodplain in confined by roads and development, but a substantial riparian corridor exists upstream of Reach A (for example, there is potential for replacement of a culvert in Reach D). Placement of LWD, in addition to riparian planting, would combine short- and long-term enhancement potential for instream habitat complexity. Floodplain reconnection and acquisition/easements in private property areas may also be possible and would protect existing riparian areas.

Table 6-3. Summary of Protection, Enhancement and Restoration Opportunities for May Creek Shoreline

Opportunity	Reach			
	A	B	C	D
Riparian	●	●	●	●
LWD Placement	●	●	●	●
Streambank				●
Floodplain/Offchannel Restoration		●	●	●
Passage Improvement				
Acquisition		●		
Community Outreach		●		●

Table 6-4. Summary of Process Alterations and Management Potential, May Creek Shoreline

Process	Scale	Alterations	Restoration Potential
Hydrology: Inputs	Watershed	<u>Moderate</u> Loss of forest cover and increased impervious area have contributed to altered peak flows which in turn affects other processes such as sediment inputs, water quality, and nutrient cycling	<u>Moderate</u> High potential for protection and restoration of floodplain and depressional wetlands in May Valley and other rural areas
	City	<u>High</u> High degree of impervious surfaces have increased stormflows by an order of magnitude	<u>Low</u> Build-out is already relatively high within the City limits, but strategic protection of remaining sensitive areas is possible
Hydrology: Groundwater Recharge	Watershed	<u>Moderate</u> Loss of forest cover is substantial but impervious surface area still moderate.	<u>High</u> Infiltrative areas on the upland plateau can be protected and restored to ensure continued summer baseflow function
	City	<u>High</u> Little forest cover remains outside of May Creek corridor and impervious surface area is very high	<u>Low</u> Limited opportunity for restoring forest cover or removing impervious surfaces in areas with high infiltration rates
Hydrology: Surface Water Storage	Watershed	<u>Moderate</u> Rural land-uses may have destroyed wetlands and floodplain connectivity in May Valley and tributaries as a result of actions undertaken to prevent property damage. However, currently there is evidence that maintaining wetland functionality might protect property from flood damage.	<u>High</u> Protection of existing storage and restoration of floodplain connectivity and depressional wetlands is possible. Easements and acquisitions are two appropriate management tools
	City	<u>High</u> Loss of associated wetlands and floodplain connectivity in Renton Highlands. Depressional wetland loss in lowland areas	<u>Low</u> Engineering solutions are most appropriate, including BMPs for stormwater management

Table 6-4. Summary of Process Alterations and Management Potential, May Creek Shoreline (continued)

Process	Scale	Alterations	Restoration Potential
Hydrology: Groundwater Movement	Watershed City	Moderate Roads and artificial drainage limit movement and increase outflow, respectively; groundwater withdrawals for both rural residential development and City of Renton	Low Limited ability to actively manage existing development and withdrawals required for human drinking water. Agricultural water easements may be possible.
Sediment: Inputs	Watershed	High Increasing stormflows have increased streambank erosion on upland plateau Developing and other disturbed areas have increase fine sediment inputs	High See hydrology sections for management scenarios BMPs for disturbed sites, particularly close to aquatic areas, including artificial conveyances such as roads, ditches, and sewers.
	City	High Increasing stormflows have increased streambank erosion High level of existing buildout limits amount of disturbed areas	Low See hydrology sections for management scenarios Bank stabilization projects in May Creek gorge can improve bank stability and prevent further channelization.
Sediment: Storage	Watershed	Moderate Rural land-uses may have destroyed wetlands and floodplain connectivity in May Valley and tributaries. However, currently there is evidence that maintaining wetland functionality might protect property from flood damage.	High Protect existing storage and restoration of floodplain connectivity and depressional wetlands. Easements and acquisitions are two appropriate management tools. Restore buffers and add LWD to streams to increase roughness and facilitate sediment deposition
	City	High Loss of associated wetlands and floodplain connectivity on Renton Plateau. Depressional wetland loss in lowland areas	Low Engineering solutions are most appropriate, including BMPs for stormwater management
Water Quality: Inputs	Watershed	High Increased nitrogen and fecal inputs from animal and septic waste. Increased phosphorus and toxins from roads and agricultural and residential areas	High Restore riparian function in headwater streams. Restore historic wetlands on upland plateau with clay or organic soils to improve removal of nitrogen and pathogens. Wetlands should be located between sources and receiving water body. Depressional wetlands in general support water quality through adsorption and removal and sequestration o

Table 6-4. Summary of Process Alterations and Management Potential, May Creek Shoreline (continued)

Process	Scale	Alterations	Restoration Potential
	City	High Toxins and other contaminants from roads and nutrients from residential areas	Low Protect/restore forested buffers and wetlands between sources and aquatic habitat. BMPs and other engineered solutions may be the most viable option
Water Quality: Storage	Watershed	Moderate Rural land-uses have destroyed wetlands and floodplain connectivity in May Valley and tributaries to augment land-use and prevent property damage.	High Protect existing storage and restoration of floodplain connectivity and depressional wetlands. Easements and acquisitions are two appropriate management tools. Restore buffers in key areas between sources and aquatic habitat
	City	High Loss of associated wetlands and floodplain connectivity on Renton Plateau. Depressional wetland loss in lowland areas	Low Restoration/enhancement possible in May Creek floodplain
Organic Matter	Watershed City	High Deforestation of riparian corridors has decreased LWD recruitment potential and degraded instream habitat complexity.	High Reach-scale reforestation of riparian areas throughout watershed. Emphasize areas with streambank instability to increase bank stability and instream sediment storage potential.
Other	Watershed City	High Increased water temperature resulting from riparian disturbance and to a lesser extent decreased summer baseflows	High Reach-scale reforestation of riparian forest cover

6.2.2 Ecological Productivity: Opportunities and Constraints by Reach

6.2.2.1 May Creek Reach A

Reach A extends from the mouth of the creek to the Lake Washington Boulevard bridge. The stream was re-routed in the 1920s to accommodate industrial development and moved from its central location across the alluvial fan/delta to the east edge. The stream is completely straightened with little naturalized riparian, suggesting a high degree of modification to prevent channel migration and flooding. The recent Barbee Mill subdivision has included extensive vegetation planting in a narrow riparian corridor extending about 35 feet on each side of the channel. There has been armoring associated with the BNSF railroad crossing; however, the abutments are set back from the OHWM. The replanting of the riparian buffer with native vegetation will result in mature vegetation over time that will provide overhanging vegetation that will improve shoreline refuge habitat for young salmon and other aquatic species, provide a source of food (insects) for young salmon and other fish, as well as contribute to temperature control.

Opportunities for maintaining and enhancing ecological productivity in this reach are limited to the narrow buffer area outside the adjacent residential lots. Because this area has been revegetated, the major actions that can best provide the buffer functions within the narrow corridor are to ensure survival of the plantings and control of invasive species. If informal public use leads to trampling of vegetation and a network of informal trails, fencing of the existing trails should be considered.

Constraints largely relate to the narrow width of the buffer, which is not likely to change given the adjacent residential development.

6.2.2.2 May Creek Reach B

Reach B extends between Lake Washington Boulevard and I-405 within a 5.5-acre undeveloped parcel zoned for residential use. Armoring is associated with the Lake Washington Boulevard and I-405 grades where they cross the stream at each end of Reach B. The stream section between the roads is relatively unaltered.

Opportunities for maintaining and enhancing ecological productivity in this reach relate largely to ensuring that future private development preserve an intact buffer area of native vegetation that will provide a variety of functions for aquatic and terrestrial habitat. Future development also should consider water quality and increased flow.

Constraints largely relate to the placement of the stream in relation to topography and future site layout for roads, lots, and public facilities such as stormwater control.

6.2.2.3 May Creek Reach C

Reach C extends from I-405 to the alignment of Northeast 36th Street and is bounded by I-405 on the west and Jones Road on the east. The stream flows through the I-405 EOW of publicly-owned land in the majority of the reach. The stream flows through a large, undeveloped privately-owned parcel just east of the I-405 crossing and adjacent to three residential lots just north of Northeast 36th Street. A portion of streambank in upper Reach C appears to be armored where it flows parallel to Jones Avenue (200 feet) and a portion of the right streambank appears to be modified to protect a private residence (500 feet).

Opportunities for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place or where invasive species have become established. Future development of the large privately owned parcel should preserve an intact buffer area of native vegetation. Existing residential lots are of moderate size and generally with a depth of 150 to 200 feet, which requires flexibility for location of homes while providing riparian vegetation buffers.

Constraints relate largely to the existing residential lots that currently provide a narrow buffer and may contribute stormwater runoff that may include herbicides and pesticides from lawns and ornamental vegetation. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation by private property owners.

6.2.2.4 May Creek Reach D

Reach D extends from Northeast 36th Street to the City limits. It is largely bounded by the King County May Creek Park or open space tracts set aside in residential subdivisions. Near the end of the reach, four single-family residences (on lots of 1 to 5 acres in size) have cleared an area relatively close to the stream. There are several road crossings to serve these residences. Except for this area, buffers generally are in the range of 200 to 600 feet.

Opportunities for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place or where invasive species have become established. Future development of the privately owned parcel may provide the opportunity to relocate development away from the stream with preservation and replanting of a buffer area and elimination of road crossings. The existing residential lots are of a size that would likely cause future subdivision.

Constraints relate largely to the existing residential lots that currently provide a narrow buffer that (a) reduces wildlife habitat functions and (b) may contribute stormwater runoff that may include herbicides and pesticides from lawns and ornamental vegetation. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring is likely to take place when these large parcels are subdivided. Educational and voluntary programs are also likely to be an important element in leading to changes in management of riparian vegetation by private property owners.

6.3 CEDAR RIVER

6.3.1 WRIA Recovery Plan

The WRIA 8 Chinook Recovery Plan used the Ecosystem Diagnostic Tool to assess the degree of watershed function in Cedar River subbasins (King County DNR 2005). As described above, processes are relatively intact in the upper watershed above the Landsburg Diversion, suggesting these subbasins should be prioritized for protection. Rock Creek, Taylor Creek, Peterson Creek, and the Walsh Lake diversion each contain extensive wetland complexes and provide high quality, intact riparian and aquatic habitat (Kerwin 2001).

The middle and lower reaches of the mainstem (below the Landsburg diversion at RM 21.6) have a high degree of process function and a large capacity for ecological function. Moderate land-use alterations make these mainstem reaches a high priority for restoration (Table 5-5). Within the City, the high degree of build-out and existing alteration on the Cedar River limits opportunities for floodplain restoration and riparian enhancement.

The main tributaries in the lower watershed (downstream of the Landsburg Diversion) include Taylor Creek, Orting Hills Creeks, Rock Creek, Maplewood, Molasses, and Madsen Creeks. These subbasins are highly altered and provide limited process and ecological function relative to the mainstem. King County DNR (2005) rates them as a low priority for restoration.

Within the City, floodplain connectivity is the primary limiting factor. While riparian condition is also degraded, its potential influence is limited because water, sediment, and other materials are not transported and stored in the floodplain.

Reaches A and B are highly-urbanized, and the channel is essentially a canal. Spawning does occur in these reaches, and both are used as salmon viewing areas, but habitat enhancement potential is very low (Table 5-6). Open space in Reaches C and D provides some limited opportunities for functional enhancement of the floodplain and riparian corridor. Instream habitat projects may be possible, but would have to be implemented giving appropriate foresight to concerns regarding potential flooding and property damage.

Table 6-5. Summary of Protection, Enhancement and Restoration Opportunities for Cedar River

	Reach			
Opportunity	**A**	**B**	**C**	**D**
Riparian			●	●
LWD Placement	●	●	●	●
Streambank			●	●
Floodplain/Offchannel Restoration			●	●
Passage Improvement				
Acquisition			●	●
Community Outreach	●	●		

Table 6-6. Summary of Process Alterations and Management Potential, Cedar River Shoreline

Process	Scale	Alterations	Restoration Potential
Hydrology: Flow regime	Watershed	High Forest cover exists in rain-on-snow zones Extensive impervious areas in lower watershed increase storm flows System dammed and managed for drinking water	Moderate Protect existing forest cover in rain-on-snow zones Restore forest and limit impervious development in areas of high infiltration
	City	High Impervious areas on upland plateaus and lowland floodplain limits recharge	Low High impervious area and artificial drainage limits potential for restoration/protection. Stormwater BMPs are primary management option.
Hydrology: Groundwater Recharge	Watershed	Moderate Forest conversion extensive but impervious surfaces outside urban areas remains at a manageable level	High Limit development and restore forest cover in aquifer recharge areas
	City	High High degree of forest cover loss and impervious surface	Low Existing land-use limits potential for restoration. Likely some areas with potential for protection in upland plateaus, particularly areas of coarse outwash deposits
Hydrology: Surface Water Storage	Watershed	High Loss of floodplain connectivity and associated wetlands on the mainstem and tributaries below Landsburg diversion limits storage short-term storage potential	High Wetland and floodplain restoration more feasible in rural areas but must be reconciled with existing land-uses
	City	High Loss of floodplain connectivity and associated wetlands on the mainstem and tributaries limits storage short-term storage potential	Low High level of urbanization limits restoration potential within the City . Levee setbacks on the mainstem may be possible in some areas
Hydrology: Groundwater Movement	Watershed	High	Moderate
	City	Moderate	Moderate

Process	Scale	Alterations	Restoration Potential
Sediment: Inputs	Watershed	High Altered hydrology destabilizes tributary ravines. Artificial stabilization of hillslopes adjacent to Cedar River limits natural spawning gravel inputs.	High Priority management actions are to improve storage potential and gravel inputs along the mainstem through floodplain reconnection and protection of erosional hillslope areas adjacent to the river. To a lesser extent, the management of hydrology and floodplain wetland restoration in tributaries in the lower watershed can improve hydrology and reduce fine sediment inputs Protection of intact tributaries and associated wetlands will prevent increases in fine sediment inputs downstream
	City	Moderate Build-out is extensive, limiting the number of disturbed areas that could contribute fine sediment	Low Limit new development in erosional areas Use BMPs for sediment control in developing areas
Sediment: Storage	Watershed City	High Wetland and floodplain loss prevents fine sediment storage in mainstem and to a lesser extent in tributaries	Moderate Levee setbacks on mainstem to increase amount of storage areas Protection of existing riparian and wetlands in developing areas
Water Quality: Inputs	Watershed	High Residential and agricultural land-uses in lower and middle watershed increase nutrient and pathogen inputs	Low No natural sources of pollution have been altered. Anthropogenic sources of pollution can be reduced using BMPs to reduce inputs from septic tanks, agriculture, and roads. Reduction in fine sediment inputs would also reduce input of absolved materials
	City	High Urban land-uses increase toxin inputs from roads and industrial sites	Low Limited potential for restoration/protection, but management of fine sediment can prevent absolved contaminants from entering water bodies.
Water Quality: Storage	Watershed	High Loss of floodplain and wetlands decrease capacity for contaminant storage	High Wetland and floodplain restoration more feasible in rural areas but must be reconciled with existing land-uses
	City		Moderate Wetland and floodplain restoration are not as feasible as in rural areas due to level of development, but riparian restoration

Table 6-6. Summary of Process Alterations and Management Potential, Cedar River Shoreline (continued)

Process	Scale	Alterations	Restoration Potential
			in possible in low-order tributaries
Organic Matter	Watershed	High Loss of high-quality mature mixed and coniferous forests limits LWD recruitment potential Loss of channel migration in mainstem and unconfined tributaries limits LWD recruitment potential	High Restore riparian corridors and channel migration in lower and middle Cedar River reaches. Restore riparian corridors in Maplewood, Molasses and Madsen Creeks to improve hydrology, sediment, water quality, and LWD processes. Protect intact tributaries and mainstem reaches in upper watershed.
	City		Moderate Potential for improving LWD recruitment potential is low on the Cedar without both restoration of mature forest and channel migration
Other	Watershed City	High Poor riparian conditions increase water temperature	High Restore riparian corridors throughout watershed

6.3.2 Ecological Productivity: Opportunities and Constraints by Reach

6.3.2.1 Cedar River Reach A

Reach A extends from the Cedar River mouth upstream to the Logan Avenue bridge. The river is constrained to a straight channel by the dikes and fill that provide the land on which the Renton Airport and Boeing Plant are constructed. Reach A is a very low-gradient, depositional area with substrate that has high levels of fine sediment. Reaches A and B were channelized by watershed realignment following the decrease in Lake Washington elevation in 1916. These reaches were routinely dredged in the past for flood control with portions most recently dredged in 1998. The levees along the river are certified by the Corps and are subject to restrictions on vegetation composition and size to maintain the integrity of the structures.

The river is primarily run-type habitat with little habitat complexity and is used by salmonids primarily as a migratory corridor for returning adults and downstream migrating juveniles. Longfin smelt (*Spirinchus thaleichthys*) also migrate and spawn in this area. Resident fish such as prickly sculpin (*Cottus asper*) are also common in these reaches. The sculpins are substantial predators of juvenile salmon (Tabor et al. 1998).

Land use on the eastern shore of the river is the City of Renton Cedar River Trail Park. The certified flood control levee is in the eastern portion of this linear park, which has allowed plantings of trees and shrubs adjacent to the shoreline. The western shore of the river is bounded by the municipal airport. This reach has flood control walls and levees that are subject to restrictions on vegetation.

Opportunities for maintaining and enhancing ecological productivity range from minor enhancements to riparian vegetation within the scope of the existing flood control facilities; to removal of hardened shorelines, which would require substantial changes to flood control facilities; to substantial reconfiguration of the river to provide more natural stream character, which likely would take place only with substantial redevelopment of adjacent uses.

Vegetation enhancement to encourage additional and more complex vegetation communities with overhanging vegetation would provide increased refuge habitat for young salmon and some food resources. This could be accomplished within the scope of the existing flood control facilities along the shoreline of the park on the eastern bank, but only within the area between the water’s edge and the prism of the formal levee. Vegetation enhancement adjacent to the municipal airport on the west bank would require a plant community limited to shrubs and small trees and would probably require periodic trimming.

Removal of hardened shorelines to decrease habitat favorable to introduced prickly sculpins, which are a predator of native salmon, would require substantial changes to flood control facilities.

More extensive natural channel conditions, that might include construction of low-velocity embayments or side channels, could provide habitat that would allow juveniles to interrupt their rapid migration through the lower reaches of the Cedar River. This would allow this reach to function as a rearing area, rather than primarily as a migration corridor. Sufficient space to accomplish this level of modification would require substantial reconfiguration of the municipal airport, which probably would occur only with redevelopment.

Constraints to maintaining a denser and more complex vegetation community on the park shoreline relate largely to the design goals of the park in providing areas for picnicking and other active uses, as well as visual access to the shoreline from the trail. Additional plantings would tend to block views to the water. This could be accommodated by side trails leading to viewing areas on the shoreline, but would involve additional capital and maintenance expense. Under current rules for levee maintenance, the lawn areas on the levee could not be replaced by native trees.

Constraints to providing additional vegetation on the municipal airport frontage relate both to maintenance standards for flood control facilities and the potential aviation hazard in attracting increased populations of birds.

Changes to the existing flood control levees could not occur without substantial changes in surrounding uses, or modification of the North Boeing bridge, which is a partial impediment to peak flood flows. Some changes to riprap materials to provide habitat less suited to prickly sculpins habitat may be possible.

Existing development is the primary constraint to larger-scale enhancements associated with a more natural channel including off-channel habitat. If the airport should be redeveloped in the future, in conjunction with redevelopment of the Boeing Plant, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

6.3.2.2 Cedar River Reach B

Reach B extends from the Logan Avenue bridge to the I-405 bridges. This portion of the river is constrained to a straightened channel and has a low gradient with substrate that has high levels of fine sediment. This reach is primarily run-type habitat with little habitat complexity and is used by salmonids primarily as a migratory corridor for returning adults and downstream migrating juveniles. Some salmon spawning does occur in this area.

The majority of Reach B is characterized by a narrow corridor of public ownership managed by the City as successor to Commercial Waterway District No. 2. The Renton Senior Center is located on the north side of the river east of Logan Avenue with a park maintenance facility adjacent to it that extends to Williams Avenue. The north side of the river is generally bounded by public streets to Bronson Way. There is a paved public pedestrian trail on the north side of the river a few feet above the OHWM between Logan Avenue and Bronson Way with a narrow fringe of grasses and shrubs between the trail and the river. The private land to the north of the public street is single-family residential. Liberty Park is located on the north side of the river between Bronson Way and Houser Way. The park is primarily active recreation fields. The banks of the river are heavily vegetated and there are pedestrian trails beyond the top of the bank.

The south side of the river is largely bounded by single-family, multi-family, and commercial uses outside of the narrow strip of public ownership. There is a continuous public trail along the upper bank and a public street between Williams Avenue and Wells Avenue. There is a small public playground east of Wells Avenue. The Renton Library spans the river between Bronson Way and Houser Way. The majority of the riverbank on the south side consists of deciduous trees and ornamental shrubs from the top of the bank to the OHWM.

Opportunities for maintaining and enhancing ecological productivity in this reach are largely limited to public lands along the river. Vegetation enhancement to encourage additional and more complex vegetation communities with overhanging vegetation would provide increased refuge habitat for young salmon and some food resources. The location where this would be most effective would be where the existing paved pedestrian trail is located next to the water. Elsewhere, the vegetation community could be enhanced in density and complexity and extended farther from the water's edge in areas such as Liberty Park.

Constraints are present in the existing private development along both sides of the river outside public ownership, as well as the public roadways. Extending vegetation into the road rights-of-way would require alternative access for adjacent private parcels where the roads are the exclusive access. Displacing the existing public trail involves tradeoffs between the SMA goals of public access and ecological restoration. Public access along the top of the bank would provide less immediate access to the water's edge.

6.3.2.3 Cedar River Reach C

Reach C extends from the I-405 bridge to the SR 169 bridge. The south side of the river is largely public open space. The Cedar River Trail on the old Milwaukee Road Railroad right-of-way is set back from the river except near I-405 and at the bridge crossing.

On the north side, the first 700 feet of river frontage are part of the City of Renton Cedar River Park. The next upstream area of about 1,400 feet is a highly altered hardened band from a former concrete batch plant with virtually no vegetation cover. The next 2,500 feet is similarly altered multi-family and commercial sites. SR 169 fronts closely on the shoreline for an additional 1,200 feet with little area for riparian vegetation. East of the former railroad bridge carrying the Cedar River Trail, the north shoreline is single-family residential for about 6,000 linear feet (1.13 miles) and immediately to SR 160 for another 1,000 feet. This portion of the reach is hardened to varying extents with minimal native vegetation in most areas. Most of the residential lots have lawn or ornamental vegetation extending to the water's edge.

Opportunities for maintaining and enhancing ecological productivity on the south side of the river would include maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place in the past near I-405. Opportunities on the north side include additional building setbacks, removal of hardened banks and provision of a buffer area of native vegetation. There is a likely short-term opportunity to accomplish this at the former concrete batch plant with consideration of tradeoffs between public access and ecological enhancement required for location of non-water-oriented mixed uses, including retail/restaurant, office, or multi-family uses. The residential lots are of moderate size and generally with a depth of 150 to 250 feet, which requires flexibility for location of homes while providing riparian vegetation buffers.

Constraints relate largely to the existing high intensity of development on this reach or the location of a state highway adjacent to the stream. The residential lots provide opportunities for native vegetation adjacent to the shoreline; however, the opportunity to apply regulations would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. As for Lake Washington Reach A, considering existing land cover as nonconforming would allow enhancement when a threshold of percent of floor area or value added to a residence would trigger compliance with new standards. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation. However, they are not likely to result in substantial changes to overall coverage of mature riparian vegetation. The large parcels with high intensity zoning allowing mixed-use development can be expected to redevelop as market opportunities dictate over the next decade or so.

6.3.2.4 Cedar River Reach D

Reach D retains the most intact channel characteristics in the city, although the river channel is constrained by flood control levees. The City owns all of the south side of the river to the City limits as Maplewood Park or Ron Regis Park. The north side of the river is owned by the City, is open space dedicated as part of subdivisions, or is large undeveloped parcels. This reach is the least constrained reach within the City, allowing a small degree of meandering, channel migration and development of gravel bars. It has a significant amount of LWD due to the landslide caused by the Nisqually Earthquake in 2001, including log-jams adjacent to Ron Regis Park. Riparian vegetation width generally ranges from about 100 to over 500 feet, although one fairway north of the river comes within about 80 feet of the river. Three off-channel salmon spawning channels have been constructed on the south side of the river adjacent to the golf course.

Opportunities for maintaining and enhancing ecological productivity throughout the reach includes maintenance of existing natural vegetation, with the potential for enhancement in a few cases to add density and complexity. Opportunities to allow additional meandering and channel migration through relocating or eliminating flood control facilities must be balanced with maintaining existing off-channel spawning channels. Future development of the remaining privately owned parcels should accommodate substantial riparian buffers.

Constraints relate largely to the existing high intensity of development on this reach or the location of a state highway adjacent to the stream. The residential lots provide opportunities for native vegetation adjacent to the shoreline; however, the opportunity to apply regulations would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. As for Lake Washington Reach A, considering existing land cover as nonconforming would allow enhancement when a threshold of percent of floor area or value added to a residence would trigger compliance with new standards. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation. However, they are not likely to result in substantial changes to overall coverage of mature riparian vegetation. The large parcels with high intensity zoning allowing mixed-use development can be expected to redevelop as market opportunities dictate over the next decade or so.

6.4 GREEN RIVER

The Green River does not flow within the City, and shoreline area is limited to a small, developed corridor separated from the River by levees and the BNSF railroad.

Reach A consists of the Black River below the pump station. It is the only portion of the Green River Basin within the shoreline planning area that has a hydraulic connection to the river. Although most of the historical floodplain was likely wetland, the channel has been channelized and realigned and no wetlands are known to occur within the shoreline planning area. The riparian corridor west of 68th Avenue South Bridge is typically 80 to 150 feet wide on the south side and 50 to 100 feet wide on the north side. The riparian buffer widens between the bridge and the pump station to about 150 feet. Vegetation within the buffer is primarily small- to medium-sized deciduous trees and emergent vegetation. East of 68th Avenue, the riparian area is the City of Renton Black River

Riparian Forest and Wetland discussed in more detail under Black River/Springbrook Creek Reach A.

Opportunities for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing buffer vegetation, with the potential for enhancement to provide greater density and complexity or removal of invasive species.

Constraints relate largely to the existing industrial development with buildings and parking lots adjacent to the buffer. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring would occur only as major remodeling or replacement of buildings occurred and is not considered likely in the near future. Education programs for property owners and voluntary programs or public funding may lead to enhanced management of riparian vegetation.

6.5 BLACK RIVER/SPRINGBROOK CREEK

6.5.1 Overview

The extent of development in the Black River/Springbrook Creek watershed severely limits the potential for restoration. Conditions are similar both within and outside of the City; the Cities of Kent and Auburn comprise much of the remaining watershed.

Increased inputs of water, sediment, and contaminants are difficult to manage directly using process-based restoration; restoration potential is probably higher for storage areas in riparian corridors and wetlands. Wetland loss in the watershed is extensive, and any existing undeveloped open space along the mainstem likely has potential for wetland restoration or re-creation. Ongoing wetland enhancement and restoration is currently occurring as part of a joint effort by WSDOT and the City to create a wetland mitigation bank (see Section 4.5.2.1).

Because the stream gradient is virtually flat, morphologic complexity is highly dependent on sinuosity and LWD that create habitat features through scour during bankfull flows. Channelization and loss of forested riparian features have limited the potential for creating complex habitat through this mechanism. A 200-foot stream corridor remains essentially undeveloped throughout the shoreline, thus the potential for riparian restoration/enhancement is high.

The potential for riparian ecological enhancement exists in most Reaches, and restoration of the floodplain and associated wetlands is underway. More potential remains, particularly for riparian enhancement and restoration. Reaches B and C have extensive existing development, limiting restoration/enhancement opportunities to the streambank as indicated in Tables 5-7 and 5-8.

Table 6-7. Summary of Protection, Enhancement and Restoration Opportunities for Black River/Springbrook Creek

	Reach		
Opportunity	**A**	**B**	**C**
Riparian	●	●	●
LWD Placement	●	●	●
Streambank restoration			●
Floodplain/Offchannel Restoration	●		●
Passage Improvement	●		●
Acquisition			●
Community Outreach	●		

6.5.2 Ecological Productivity: Opportunities and Constraints by Reach

6.5.2.1 Black River/Springbrook Creek Reach A

Reach A extends from the pump station to Grady Way. Immediately upstream from the pump station the reach is contained in a large pond. The riparian corridor in this reach is primarily forested, and more than 250-feet-wide on either bank. However, invasive reed canarygrass (*Phalaris arundinacea*) is also dominant in areas, particularly in the shoreline on the left bank where there is public access and a trail system. This area also hosts a heron rookery with approximately 90 nests.

The stream then flows through a 100- to 150-foot-wide vegetated corridor bounded on the east by Oakesdale Avenue and on the west by the Metro Sewage Treatment Plant. A combination of deciduous forest and open canopy emergent areas extend 30 feet on river left and 80 to 100 feet on river right. The stream then flows under two local streets and I-405, with highly altered riparian conditions.

Opportunities for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing buffer vegetation, with the potential for enhancement to provide greater density and complexity and removal of invasive species. Local community groups have sponsored a series of work parties to restore native vegetation, in cooperation with the Renton Parks Department (Herons Forever 2008).

Constraints relate largely to the surrounding development, roads that allow little opportunity to expand buffers, and the crossings under city streets and I-405 that include bank armoring and little opportunity for riparian vegetation due to shading and lack of water.

Table 6-8. Summary of Process Alterations and Management Potential, Black River/Springbrook Creek Shoreline

Process	Scale	Alterations	Restoration Potential
Hydrology: Inputs	Watershed City	<u>High</u> Impervious surfaces and artificial drainage reapportions precipitation from infiltration to surface runoff	<u>Low</u> Restoration potential is very low due to extensive build-out. Stormwater BMPs are primary management tool
Hydrology: Groundwater Recharge	Watershed City	<u>High</u> Extensive impervious development coarse alluvial deposits on the historic Green River floodplain and infiltrative soils in headwater plateaus limit recharge potential	<u>Low</u> Protect few existing upland areas underlain by soils with high infiltration rates
Hydrology: Surface Water Storage	Watershed City	<u>High</u> Wetland conversion and channelization of both Green River and Springbrook Creek reduce floodwater storage potential	<u>Moderate</u> Restoration of floodplain and storage would improve flood attenuation in Springbrook Creek and to a lesser extent the Green River
Hydrology: Groundwater Movement	Watershed	<u>Moderate</u> Road embankments and extensive diking along Green River likely modifies groundwater flow. City of Kent groundwater withdrawals likely affect groundwater movement and availability for discharge to streams	<u>Low</u> In addition, groundwater flow patterns are not well understood Low potential for restoring historic groundwater flow patterns. Potential for levee setbacks on Green River to restore shallow groundwater flow regime in floodplain is low
	City	Extensive diking along Green River likely	

Process	Scale	Alterations	Restoration Potential
		modifies groundwater flow.	
Sediment: Inputs	Watershed City	High Build-out is extensive, but disturbed areas in developing areas and high road density still contribute large amounts of fine sediment	Moderate Limit development in erosional areas, and use BMPs for sediment input in developing areas Protect and restore lowland floodplains and historic wetlands
Sediment: Storage	Watershed City	High Wetland conversion and channelization of both Green River and Springbrook Creek reduce storage potential	Moderate Restoration of floodplain and wetlands would improve storage capacity
Water Quality: Inputs	Watershed City	High Industrial land-uses have led to high concentrations metals	Moderate Protect and restore lowland floodplains and historic wetlands Protect and restore riparian vegetation in low-order streams between developed areas and streams.
Water Quality: Storage	Watershed City	High Similarly to water and sediment storage, wetland conversion and channelization of both Green River and Springbrook Creek reduce storage potential	Moderate Restoration of floodplain and wetlands would improve storage capacity Restore native cover in riparian corridors to improve biotic uptake of contaminants
Organic Matter	Watershed	High Lack of LWD recruitment in conjunction with hydromodification has limited instream habitat complexity	High Riparian areas in streams with existing salmonid spawning and rearing
	City	Moderate Although no mature forest exists, most of Springbrook Creek has retained a modest riparian corridor.	High Enhancement potential for existing riparian corridor is high, including removal of invasive species and long-term restoration of mature mixed forest
Other	Watershed City	High Impaired temperature resulting from lack of riparian cover and reduced baseflow Reed canary grass infestations limit recruitment of native riparian vegetation	Moderate Riparian areas can be enhanced to provide shade. Restoration of baseflows is more problematic due to low potential for restoring groundwater recharge to historic levels

6.5.2.2 Springbrook Creek Reach B

Reach B extends from Grady Way to Southwest 16th Street, and is intersected by a major state interstate corridor. It has not undergone restoration and has some natural corridor open space between Grady Way and I-405 and between I-405 and Southwest 16th Street. Riparian width varies from a minimum of 80 feet to a maximum of 180 feet, with an average width of 130 feet.

Opportunities for maintaining and enhancing ecological productivity in this reach are limited to vegetative restoration and replantings. The public access trail running along the southwest edge of the riparian area could provide incentive for restoration to enhance public enjoyment by augmenting vegetative cover and stream health.

Constraints relate largely to the reach being bounded by several high-capacity roadways.

6.5.2.3 Springbrook Creek Reach C

Reach C extends from Southwest 16th Street to City Limits. It has undergone restoration and has a natural corridor open space in Boeing Longacres Industrial Park. Between 16th and 19th Street, riparian width varies between 60 and 80 feet on the north bank of the stream. The south bank is bounded by a 5-acre wetland restoration site.

From 19th Street until City limits, the stream channel is owned and maintained by King County Drainage District #1. Maintenance includes removal of most native vegetation from the streambanks, except where the stream flows through wetland mitigation sites between Southwest 23rd Street and Southwest 30th Street. A small stretch of the stream from Southwest 41st Street to Southwest 43rd Street has a moderate cover of small deciduous trees. Where vegetation is removed by the drainage district, cover is dominated by reed canarygrass and provides little buffer function.

Opportunities for maintaining and enhancing ecological productivity relate to maintenance of existing buffer vegetation where it is present with the potential for enhancement to provide greater density and complexity and removal of invasive species. Where the drainage district removes native vegetation from the streambanks, a vegetation management plan would greatly enhance a range of buffer functions. The plan would provide for native vegetation while allowing the drainage and conveyance functions of the channel. The buffer functions would include refuge habitat for young salmon, food sources, and shading to control temperature. The drainage district should examine their vegetation maintenance programs in light of the mandate in RCW 90.58.340 for all state agencies, counties, and public and municipal corporations to review administrative and management policies, regulations, plans, and ordinances relative to lands under their respective jurisdictions adjacent to the shorelines of the state so as to achieve a use policy on said land consistent with the policy of this chapter, the guidelines, and the master programs for the shorelines of the state.

Constraints relate largely to the location of surrounding development, which often includes buildings and impervious surfaces up to the drainage district ROW. This adjacent land, however, can be expected to redevelop over the long term and provide opportunities for additional vegetated buffer area.

6.6 LAKE DESIRE

6.6.1 Overview

Priority restoration and protection areas are related to water quality. Protecting and restoring existing wetlands between the Lake and residential developments in conjunction with riparian restoration in tributary streams will improve precipitation of adsorbed phosphorus before reaching the Lake and augment biotic uptake of nitrogen and fecal coliform.
Existing wetlands occur along the north and southeast shorelines but are not bordered by residential land. Areas of residential development along the rest of the shoreline extend to the lake edge and limit potential for restoration of lost wetlands. Sensitive peat wetlands also exist on the northern shore of Lake Desire. Riparian areas both in tributary streams and along the lakeshore, especially peat wetlands on the northern shore of Lake Desire, should be prioritized for protection and restoration. Protection of existing migratory corridors connecting Lake Desire shoreline to other natural areas is also a high priority.

6.6.2 Ecological Productivity: Opportunities and Constraints by Reach

6.6.2.1 Lake Desire Reach A

Reach A extends from 17408 West Lake Desire Dr. Southeast to 18228 West Lake Desire Dr. Southeast. It is characterized by medium intensity residential development where most natural riparian vegetation has been removed.

Opportunities include: replacing bulkheads with softer armor, adding substrate to the nearshore environment, enhancing native vegetation along the shoreline, addressing runoff through maximum impervious surface/treatment, educating existing and future adjacent property owners to reduce impacts from herbicides and pesticides, and replacing docks (as they deteriorate) with ones that are narrower in the nearshore areas and grated to allow for light passage.

Constraints relate largely to the existing developed character of the shoreline and the lack of necessity for bulkhead or dock replacement in most cases. Bulkheads made of durable materials in this area are unlikely to fail and require replacement. Docks tend to have a practical lifespan of about 20 years. Given this situation, it is unlikely that a substantial portion of the shoreline would be upgraded over a 15- to 20-year period. This is a situation where education programs and voluntary action may have more influence than regulations.

6.6.2.2 Lake Desire Reach B

Reach B extends from 17408 West Lake Desire Dr. Southeast to the Natural Area at the south end of the Lake. It is characterized by high intensity residential development.

Opportunities for maintaining and enhancing ecological productivity include all of the items listed above for Reach A designed to provide a more productive nearshore environment.

Constraints relate largely to the existing developed character of the shoreline and include consideration of issues listed under Reach A to provide a more productive nearshore environment.

6.6.2.3 Lake Desire Reach C

Reach C includes the Natural Area at the south end of the Lake.

Opportunities include maintenance of existing riparian vegetation and enhancement where clearing has taken place or where invasive species have become established.

Constraints are few, but might involve competing with successional growth rates of invasive species. There might also be some tradeoffs between public access in the Natural Area and native vegetation enhancement.

6.6.2.4 Lake Desire Reach D

Reach D extends from the Natural Area to 17346 West Lake Desire Dr. Southeast. It is characterized by medium intensity residential development.

Opportunities for maintaining and enhancing ecological productivity include all of the items listed above for Reach A designed to provide a more productive nearshore environment.

Constraints relate largely to the existing developed character of the shoreline and include consideration of issues listed under Reach A to provide a more productive nearshore environment.

7. REFERENCES

Adams, L.W. 1994. Urban Wildlife Habitats: A Landscape Perspective. University of Minnesota Press. Minneapolis, MN.

Beauchamp, D. A. 1990. Seasonal and diet food habits of rainbow trout stocked as juveniles in Lake Washington. Transactions of the American Fisheries Society 119:475-482.

Brazner, J. C. 1997. Regional, habitat, and human development influences on coastal wetland and beach fish assemblages in Green Bay, Lake Michigan. J. Great Lakes Res. 23: 36-51.

Cascadia Archaeology. 2006. Archaeological Investigations for Fifth and Williams Apartments, Renton, King County, Washington. Prepared by Jana L. Boersema.

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetlands and stream buffer size requirements—A review. Journal of Environmental Quality 23:878-882.

Castelle, A.J., and A.W. Johnson. 2000. Riparian vegetation effectiveness. National Council for Air and Stream Improvement. Tech. Bull. No. 799.

Chrzastowski, M. 1983. Historical changes to Lake Washington and route of the Lake Washington Ship Canal, King County, Washington. Dept. of the Interior, U.S.Geological Survey, Water Resources Investigation, Open-File Report, WRI 81-1182.

City of Bellevue Parks and Community Services. 2003. *Parks and Open Space System Plan.* Bellevue, Washington.

City of Renton. 2004. *City of Renton Comprehensive Plan.* Adopted November 1, 2004.

City of Renton. 2005. Impervious Surface Geographic Information System (GIS) Data.

City of Renton. 2008a. *City of Renton Municipal Code.* Current through Ordinance 5387, adopted June 9, 2008.

City of Renton. 2008b. GIS Data.

Collins, N. C., P. St. Onge, and V. Dodington. 1995a. The importance to small fish of littoral fringe habitat (Z<0.2m) in unproductive lakes, and the impacts of shoreline development. Lake and Reservoir Management 11: 129.

Cooke, G. D., E. B. Welch, S. A. Peterson, and P. R. Networth. 1993. Restoration and management of lakes and reservoirs. Lewis Publishers, Boca Raton, Florida.

Dampf, Steve and DeJoseph, D. 2005. Archaeological Isolate Form for Site #45-KI-730.

DAHP (Department of Archaeology and Historic Preservation) 2008a. Washington Information System for Architectural and Archaeological Records Data. Accessed from http://www.dahp.wa.gov/pages/wisaardIntro.htm on May 13, 2008.

DAHP (Department of Archaeology and Historic Preservation. 2008b. Washington Information System for Architectural and Archaeological Records Data (WISAARD) Summary Report for Renton Fire Station (KI-209).

DAHP (Department of Archaeology and Historic Preservation 2008c. WISAARD Summary Report for Renton Substation, Snoqualmie Falls Power Company (KI-074).

DNR (Washington Department of Natural Resources) 2009. Salmon Recovery Board, WRIA 8 Application, South Lake Washington DNR Shoreline Restoration (#3)

DNR (Washington Department of Natural Resources) 2006. Withdrawal order for Barbee Mill Beach, September 12, 2006. Dough Southerland, Commissioner of Public Lands.

Ecology (Washington Department of Ecology). 2008a. Water Quality 2002/2004 Assessments for Washington. http://apps.ecy.wa.gov/wats/WATSQBEHome.asp. Accessed May 1, 2008.

Ecology (Washington Department of Ecology). 2007. Oblique photographs of Lake Washington and Cedar River.

Ecology (Washington Department of Ecology). 2006. Oblique photographs of Lake Washington and Cedar River.

Eggers, D. M, N.W. Bartoo, N. A. Rickard, R. E. Nelson, R. L. Wissmar, R. L. Burgner, and A. H. Devol, 1978. The Lake Washington ecosystem: the perspective from the fish community production and forage base. Journal of the Fisheries Research Board of Canada 35: 1553-1571.

ESA Adolfson. 2007a. City of Tukwila Shoreline Master Program Update: Shoreline Inventory and Characterization Report. Prepared for: City of Tukwila, Tukwila, Washington. 71 pages.

ESA Adolfson. 2007b. City of Sammamish Shoreline Master Program Update: Shoreline Inventory and Characterization Report. Prepared for: City of Sammamish, Sammamish, Washington. 97 pages.

Evermann, B. W., and S. E. Meek. 1897. A report upon salmon investigations in the Columbia River Basin and elsewhere on the Pacific Coast. Bulletin of the United States Fish Commission. 17: 15-84.

FEMA (Federal Emergency Management Agency) 2007. Draft Flood Insurance Rate Map, Map No. 53033C0664K http://www.metrokc.gov/dnrp/wlr/flood/dfirm/pdf/D53033C_0664.pdf accessed June20, 2009.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: An ecological, economic, and social assessment. U.S. Departments of Agriculture, Commerce, and Interior. Portland Oregon.

Feist, B. E., J. J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (Oncorhynchus gorbuscha) and chum (O. keta) salmon behavior and distribution. Report No. FRI-UW-9603. Fisheries Research Institute, School of Fisheries, Univ. of Washington, Seattle, WA. 58 p.

Ferguson, H.L., K. Robinette, and K. Stenburg. 2001 Chapter 12 Wildlife of Urban Habitats. In Johnson, D.H. and T.A. O'Neil. 2001. *Wildlife-Habitat Relationships in Oregon and Washington*. Oregon State University Press. Corvallis, Oregon.

Foley, S. 2009 WDFW Fisheries Biologist. Personal Communication July 20, 2009

Fresh, K.L., and G. Lucchetti. 2000. Protecting and restoring the habitats of anadromous salmonids in the Lake Washington Watershed, an urbanizing ecosystem. Pages 525-544 In E.E. Knudsen, C. R., Steward, D.D. Macdonald, J.E. Williams, and D.W. Reiser (editors). Sustainable Fisheries Management: Pacific Salmon. CRC Press LLC, Boca Raton. Fresh, K. L. 1994. Lake Washington fish: a historical perspective. Lake and Reservoir Management 9:148-151.

Fuerstenberg, R.R., K. Nelson, and R. Blomquist. 1996. Ecological conditions and limitations to salmonid diversity in the Green River, Washington, USA: structure, function and process in river ecology. Draft report prepared by King County Department of Natural Resources, Surface Water Management Division. 31 p.

Galster, R.W., and W.T. Laprade. 1991. Geology of Seattle, Washington, United States of America. August 1991. Bulletin of the Association of Engineering Geologists. Vol. XXVIII, No. 3. College Station, Texas.

Gracie, James and Clar, Michael (2004): Issues in streams in restoration and protection in Michael Clar et al, edited "Protection and Restoration of urban and rural streams " , American Society of Civil Engineers (ASCE), Va.

Hall, J. L. 2002. Habitat selection by sockeye salmon (*Oncorhynchus nerka*) in off-channel ponds of the Cedar River and the implications for restoration. Thesis, University of Washington, Seattle, Washington.

Hampton. S.E, P.Romare, and D.E. Seiler 2006. Environmentally controlled Daphnia spring increase with implications for sockeye salmon fry in Lake Washington, USA Journal of Plankton Research February 2006 28(4):399-406; http://plankt.oxfordjournals.org/cgi/content/abstract/28/4/399

Hendry, A. P., T. P. Quinn, and F. M. Utter. 1996. Genetic evidence for the persistence and divergence of native and introduced sockeye salmon (*Oncorhynchus nerka*) within Lake Washington, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53:823-832.

Historical Research Associates, Inc (HRA). 2005a. *Final Archaeological, Historical, and Cultural Discipline Report for the I-405 Springbrook Creek Wetland and Habitat Mitigation Bank Project.* Prepared by Denise DeJoseph and Steven Dampf.

HRA. 2005b. *Literature Review and Archaeological Resources Field Survey BPA Covington-Maple Valley No. 2 Fiber Optic Project, King County, Washington*. Prepared by Steven K. Dampf and Gail Thompson.

Johnson, A.W., and D.M. Ryba. 1992. A literature review of recommended buffer widths to maintain various functions of stream riparian areas. King County Surface Water Management Division.

Kahler, T. 2000. A Summary of the Effects of Bulkheads, Piers, and Other Artificial Structures and Shorezone Development on ESA-listed Salmonids in Lakes. Prepared for the City of Bellevue. Prepared by the Watershed Company. July, 2009

Kahler, T.H., P. Roni, and T.P. Quinn. 2001. Summer movement and growth of juvenile anadromous salmonids in small western Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58:1947-2637

Kauffman, J.B., M. Mahrt, L.A. Mahrt, and W.D. Edge. Wildlife of Riparian Habitats. Chapter 14 in Johnson, D.H. and T.A. O'Neil. 2001. *Wildlife-Habitat Relationships in Oregon and Washington.* Oregon State University Press. Corvallis, Oregon.

Kennedy, Hal. 1985. Master Site File for Site #45-KI-267.

Kerwin, J., 2008 Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (WRIA 8). Washington Conservation Commission. Olympia. WA. P 4. http://www.govlink.org/watersheds/8/reports/DOE-Grant-Report2008.pdf (accessed July 14, 2009).

Kerwin, J., 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (WRIA 8). Washington Conservation Commission. Olympia. WA.

Kerwin, J. and Nelson, T. S. (Eds). 2000. Habitat Limiting Factors and Reconnaissance Assessment Report. Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and the King County Department of Natural Resources. http://salmon.scc.wa.gov

King County. 2009. GIS data.

King County et al., 2008. King County Shoreline Master Program, Appendix A Shorelines Protection and Restoration Plan. Third Draft, October 2008. http://www.kingcounty.gov/environment/waterandland/shorelines/program-update/draft3-shoreline-master-program-plan.aspx (Accessed July 20 2009).

King County. 2007. King County Aerial Photos. King County, Washington.

King County. 2005. King County Aerial Photos. King County, Washington.

King County. 2002. King County Aerial Photos. King County, Washington.

King County Department of Development and Environmental Services (DDES). 2006. *Land Use 2004.* Map prepared in November 2006.

King County DDES. 2008. *King County Zoning Atlas.* Map prepared June 23, 2008.

King County et al., 2005. Final Lake Washington/Cedar/Sammamish Watershed (WR1A 8) Chinook Salmon Conservation Plan, Volume 1. July 2005. King County Department of Natural Resources Water and Land Resources Division, Seattle, Washington.

King County Natural Resources and Parks. 1996 Lake Desire Management Plan, Document No. PUT 8-9 (PR) Surface Water Management Division, July 18, 1996 Available at: http://www.kingcounty.gov/operations/policies/rules/utilities/put89pr.aspx Accessed on July 22, 2008.

King County Department of Natural Resources and Parks Water and Land Resources Division. 2003. Summary of Salmon Habitat Projects. http://www.govlink.org/watersheds/8/planning/srfb-projects/project_table.aspx (accessed July 15, 2009).

King County GIS Center. 2007. *Burien, SeaTac, Tukwila, Renton Parks and Trails Map.*

King County. 2008. May Creek Water Quality. http://dnr.metrokc.gov/wlr/Waterres/streamsdata/May.htm. Accessed May 5, 2008.

King County Department of Natural Resources. 1996. Lake Desire Management Plan. Seattle, Washington.

King County 1993 Cedar River Current and Future Conditions. Report. King County Department of Public Works,. Surface Water Management Division,

King County Department of Natural Resources. 2005. Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan: Volumes I, II and III. July 2005. http://www.govlink.org/watersheds/8/planning/chinook-conservation-plan.aspx (accessed July 14, 2009).

King, County of 2005, King County Department of Parks and Natural Resources, Flood Management Division, 2006 King County Flood Hazard Management PlanKiyohara, K., and G. Volkhardt. 2007. Evaluation of downstream migrant salmon production in 2006 from the Cedar River and Bear Creek. Report FPA 07-02, Washington Department of Fish and Wildlife, Olympia, Washington. 79 p.

King, County of 2007, Management Division, 2006 King County Flood Hazard Management Plan

King, County of 2007, King County Department of Development and Environmental Services, Shoreline Master Program, Appendix E: Technical Appendix Contains: Shoreline Inventory and Characterization: Methodology and Results May 2007

King, County of 2007, King County Flood Control Zone District (KCFCZD King County Water and Land Resources Division of the King County Department of Natural Resources and Parks. Cedar Sammamish Basin Technical Committee Meeting Wednesday April 25, 2007 Agenda package http://your.kingcounty.gov/dnrp/wlr/flood/flood-control-zone-district/cedar-sammamish/btc-meeting-summary/070425-cedar-meeting.pdf

Kiyohara, K., and G. Volkhardt. 2007. Evaluation of downstream migrant salmon production in 2006 from the Cedar River and Bear Creek. Report FPA 07-02, Washington Department of http://your.kingcounty.gov/dnrp/library/water-and-land/shorelines/map-folio/technical-appendix/alterations-analysis-sw-kc.pdf

Knutson, K.L. and V.L. Naef. 1997. Management recommendations for Washington's priority habitats: Riparian. Washington Department of Fish and Wildlife. 181pp.

Koehler, M. E., K. L. Fresh, D. Beauchamp, J. R. Cordell, C. A. Simenstad, and D. E. Seiler. 2006. Diet and bioenergetics of lake-rearing juvenile Chinook salmon in Lake Washington. Transactions of the American Fisheries Society 135:1580–1591

LAAS. 1996a. *Cultural Resources Monitoring Alki Transfer/CSO Facilities Project Transfer/Interurban Project.* Prepared by Jeffrey R. Robbins, Lynn L. Larson, and Dennis E. Lewarch.

Larson Anthropological Archaeological Services (LAAS). 1996b. Cultural resource monitoring of the Waterworks Project at King County's East Division Reclamation Plant, Renton, Washington. Letter prepared by Eric W. Banks and Lynn L. Larson.

LAAS. 2003a. *Carr Road Improvements (CIP #400898) Cultural Resources Assessment, King County, Washington.* Prepared by Leonard A Forsman, Kurt W. Roedel, Dennis E. Lewarch, and Lynn L. Larson.

LAAS. 2003b. Washington Archaeological Site Inventory Form for Henry Moses Aquatic Center Site (KI-686). Recorded by Yonara Carillho and Stephanie Trudel.

LAAS. 2004. *South Treatment Plant Cogeneration Facility Archaeological Resources Assessment, City of Renton, King County, Washington.* Prepared by Stephanie E. Trudel, Dennis E. Lewarch and Lynn L. Larson.

LAAS. 2005. Final Elliot Bridge Replacement, Renton, King County, Washington. Letter prepared by Gretchen A. Kaehler and Lynn L. Larson.

LCFRB (Lower Columbia Fish Recovery Board). 2004. Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan: Volume II – Subbasin Plan, Chapter E – Cowlitz, Coweeman and Toutle. 494pp.

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welsh. 1997. Effects of Urbanization on Small Stream in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques, 2:483-494.

May, C.W. 2000. Protection of stream-riparian ecosystems: a review of best available science. Prepared for Kitsap County Natural Resources Coordinator. July 2000.

Moshenberg, K. L. 2004. A Sediment Triad Analysis of Lakes Sammamish, Washington, and Union. Prepared for: King County Dept. of Nat. Res. And Parks, Land and Water Division. Seattle, WA. 109 pgs.

MIFTD (Muckleshoot Indian Tribe Fisheries Division) 2009. Comment letter on City of Renton Draft Inventory and Characterization. Letter dated January 23, 2009

Mullineaux, D.R. 1970. Geology of the Renton, Auburn and Black Diamond quadrangles, King County, WA. USGS Professional Paper 672. 92 pgs.

Naval Historical Center. 1997. *The Wreck of the U.S. Navy Martin PBM-5 Mariner BuNo 59172: History and Archaeological Assessment.* Prepared by Richard Wills.

NMFS (National Marine Fisheries Service) 2007. Programmatic Biological Evaluation for Shoreline Protection Alternatives in Lake Washington, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112. December 13, 2007

NMFS (National Marine Fisheries Service) 2009 Endangered Species Act Section 7 Consultation, Biological Opinion, Environmental Protection Agency Registration of Pesticides Containing Carbaryl, Carbofuran, and Methomyl, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112. April 20, 2009 http://www.nmfs.noaa.gov/pr/pdfs/carbamate.pdf

Norman, L. 1996. Archaeological Site Inventory Form for Historic Debris Scatter (KI-542).

Northwest Archaeological Associates, Inc (NWAA). 2007. *Cultural Resources Assessment for the Proposed Lowe's of Renton, King County, Washington.* Prepared by Charles M. Hodges.

Nowak , G. M., R. A. Tabor, E. J. Warner, K. L. Fresh, and T. P. Quinn. 2004. Ontogenetic shifts in habitat and diet of cutthroat trout in Lake Washington, Washington. North American Journal of Fisheries Management 24:624–635.

Nowak , G. M., and T. P. Quinn. 2002. Diel and seasonal patterns of horizontal and vertical movements of telemetered cutthroat trout in Lake Washington, Washington. Transactions of the American Fisheries Society 131:452-462.

Pollock, M. M., G. R. Pess, and T. J. Beechie. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River Basin, Washington, USA. North American Journal of Fisheries Management 24:749-460.

Pollack, M.M. and P.M. Kennard. 1998. A low-risk strategy for preserving riparian buffers needed to protect and restore salmonid habitat in forested watersheds of Washington State. The Bullitt Foundation, Washington Environmental Council, and Point-No-Point Treaty Council.

Parametrix, Inc. 2003. Stream Inventory and Habitat Evaluation Report Including Issaquah Creek, East and North Forks of Issaquah Creek, Tibbetts Creek, and the Shoreline of Lake Sammamish, Final Report. Prepared for the City of Issaquah.

Puget Sound Biological Review Team (PSBRT). 2005. Status review update for Puget Sound Steelhead. National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112.

R2 Resource Consultants. 2000. Juvenile Salmonid Use of Lateral Stream Habitats Middle Green River, Washington: 2000 Data Report. Prepared for: U. S. Army Corps of Engineers, Seattle Division, Seattle, Washington.

Renton, City of, and King County. 2001. Final Adopted May Creek Basin Action Plan. Renton, Washington. 107 pgs. http://your.kingcounty.gov/dnrp/library/1998/kcr726/FINAL-May-Creek-Basin-Plan-4-16-01.pdf

Renton, City of 2003, Barbee Mill Preliminary Plat Draft Environmental Impact Statement, prepared by Parametrix Inc., September 2, 2003, Renton, WA

RW Beck 2008. Hydraluli Analysis of Springbook Creek, FEMA Re-Mapping Study. Prepared for the City of Renton, June 2006.

Reiser, D. W., E. Connor, and. K. Binkley, K. Lynch, and D. Paige. 1997. Evaluation of spawning habitat used by bull trout in the Cedar River watershed, Washington. Pages 331-338 in Mackay, W. C., M. K. Berwin, and M. Monita (editors). Friends of the Bull Trout Conference Proceedings, Trout Unlimited Canada, Calgary, Alberta.

Riley, Ann L. (1998): Restoring Streams in Cities, a Guide for Planners, Policymakers, and Citizens, Island Press, Washington D.C.

Robbins, C.S. 1991. Managing Suburban Forest Fragments for Birds. Pages 253-264 in D.J. Decker et al., eds. Challenges in the Conservation of Biological Resources: a Practitioner's Guide. Westview Press. Boulder, Colorado. Page 76 in Adams, L.W. 1994. Urban Wildlife Habitats: A Landscape Perspective. University of Minnesota Press. Minneapolis, MN.

Stanley, S., J. Brown, and S. Grigsby. 2005. *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes.* Washington State Department of Ecology. Publication #05-06-027. Olympia, Washington.

Straka, Ron. 2008 City of Renton Surface Water Utility Engineering Supervisor, Personal communication, September 2008

Tabor, R. A., M. T. Celedonia, F. Mejia, R. M. Piaskowski, D. L. Low, B Footen, and L. Park. 2004. Predation of juvenile Chinook salmon by predatory fishes in three areas of the Lake Washington basin. Unpublished report, US Fish and Wildlife Service, Lacey, Washington. 86 p. http://www.fws.gov/pacific/westwafwo/fisheries/Publications/FP224.pd

Tabor, R. A., H. A. Gearns, C. M. McCoy III, and S. Camacho. 2003. Nearshore habitat use by juvenile Chinook salmon in lentic systems, 2001 Report. US Fish and Wildlife Service, Lacey, Washington. 94 p.

Tabor, R. A., H. A Gearns, C. M. McCoy III, and S. Camacho. 2006. Nearshore habitat use by juvenile Chinook salmon in lentic systems, 2003 and 2004 Report. US Fish and Wildlife Service, Lacey, Washington. 94 p.

Tolt, J.D. 2001 Shoreline and Dock Modifications in Lake Washington, University of Washington, School of Aquatics and Fishery Sciences, Report No. SAFS-UW-0106, Prepared for King County Department of Natural Resources, October 2001

U.S. Army Corps of Engineers (USACE) 1997a Final Detailed Project Report and Environmental Impact Statement - Cedar River Section 205, June 1997.

U.S. Army Corps of Engineers (USACE) 1997b Cedar River Section 205 Flood Damage Reduction Study - Final Environmental Impact Statement, August 1997.

U.S. Geological Survey. 1998. *Determination of Upstream Boundaries on Western Washington Streams and Rivers Under the Requirements of the Shoreline Management Act of 1971*. Prepared by David L. Kresch, Water-Resources Investigations Report 96-4208. Prepared in cooperation with Washington State Department of Ecology.

Walter, Karen. 2009. Mukleshoot Tribe Fisheries Department. Email correspondence with City of Renton.

Washington Department of Fish and Wildlife Salmonid Stock Inventory (SaSI). 2008. GIS data.

Western Shore Heritage Services, Inc. 2005. *Cultural Resources Assessment for the Duvall Avenue NE / Coal Creek Parkway SE Road Widening Project, King County, Washington.* Prepared by Jennifer Chambers and Glenn D. Hartmann.

WSDOT (Washington State Dept. of Transportation). 2008. WSDOT Projects: I-405 - Springbrook Creek Wetland & Habitat Mitigation Bank. http://www.wsdot.wa.gov/Projects/i405/Springbrook/. Accessed June 3, 2008.

The Watershed Company. 2006. Shoreline Analysis Report Including Shoreline Inventory and Characterization for the City of Kirkland's Lake Washington Shoreline Tasks 3, 4 and 5. Prepared for: City of Kirkland, Kirkland, Washington. 75 pages.

Weitkamp, D. E., G.T. Ruggerone, L. Sacha, J. Howell, and B. Bachen. 2000. Factors Affecting Chinook Populations, Background Report. Report Prepared by Parametrix, Inc., Natural Resources Consultants, Inc. and Cedar River Associates. 224 p.

Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia.

Williams, R.W., R.M. Laramie and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Washington State Dept. of Fisheries, WRIA-09. 34 pp.

Wydoski, R.S. and R.R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press. Seattle, and London.

Websites

City of Renton. 2008a. City History. Available at: http://rentonwa.gov/visiting/default.aspx?id=1216&mid=9. Accessed on May 13, 2008.

City of Renton. 2008b. Port Quendall. Available at: http://rentonwa.gov/business/default.aspx?id=2062. Accessed on July 17, 2008.

City of Renton. 2008c. South Lake Washington. Available at: http://rentonwa.gov/business/default.aspx?id=2814. Accessed on July 17, 2008.

City of Renton Parks and Recreation. 2008. Master Park Directory Website. Accessed from http://rentonwa.gov/living/default.aspx?id=2328 on May 12, 2008.

City of Tukwila Parks and Recreation. 2008. Parks and Recreation Department. Accessed from http://www.ci.tukwila.wa.us/recreation/recmain.html on August 4, 2008.

Department of Ecology (Ecology). 2006. Oblique photographs of Lake Washington and Cedar River.

Department of Ecology (Ecology). 2007. Oblique photographs of Lake Washington and Cedar River.

Duwamish Tribe. 2008. The Duwamish Tribe. Available at: http://www.duwamishtribe.org/. Accessed on May 13, 2008.

King County. 2007. King County Aerial Photos. King County, Washington.

King County. 2005. King County Aerial Photos. King County, Washington.

King County Department of Assessments. 2008. *Parcel Viewer.* Available at: http://www5.metrokc.gov/parcelviewer/viewer/kingcounty/viewer.asp. Accessed on May 12, 2008.

King County Natural Resources and Parks. 2008a. South Treatment Plant. Available at: http://dnr.metrokc.gov/WTD/southplant/index.htm. Accessed on July 22, 2008.

King County Natural Resources and Parks. 2008b. Welcome to Waterworks Gardens Website. Available at: http://dnr.metrokc.gov/WTD/waterworks/. Accessed on May 13, 2008.

King County Natural Resources and Parks. 2008c. Lake Desire. http://dnr.metrokc.gov/wlr/waterres/smlakes/desire.htm. Accessed on May 5, 2008.

Muckleshoot Indian Tribe. 2008. Muckleshoot Indian Tribe Website. Available at: http://www.muckleshoot.nsn.us/. Accessed on July 25, 2008.

Tabor, R. A., and M. Celadonia 2008, Habitat use of juvenile Chinook Salmon in Lake Washington, Washington Department of Ecology Website, Shoreline Master Program (SMP) development, Regular SMP Coordination and Assistance Meetings, Summer 2008 meeting (July 24, 2008, Tukwila) PowerPoint presentation. US Fish and Wildlife Service, Lacey, Washington. Available at: http://www.ecy.wa.gov/programs/sea/sma/st_guide/SMP/download/habitat_use_of_chinook.pdf

U.S. Army Corps of Engineers (USACE). 2004c. Lake Washington Summary Hydrograph. 1997-1999. Available: http://www.nwd-wc.usace.army.mil/nws/hh/basins/lwscsh.html. Accessed: January 2008.

USFWS (US Fish and Wildlife Service). 2008. Wetlands On-line Mapper. Available: http://wetlandsfws.er.usgs.gov/wtlnds/launch.html. Accessed: May 2008.

USGS (US Geologic Survey). 2008. USGS Surface-Water Annual Statistics for Washington. Available: http://wa.water.usgs.gov/. Accessed: May 2008.

Walters, Karen 2009. Muckleshoot Indian Tribes Fisheries Division, Comments on Renton SMP Draft Inventory, Letter January 23, 2009

Washington State Department of Transportation (WSDOT). 2008. I-405 Springbrook Creek Wetland and Habitat Mitigation Bank. Available at: http://www.wsdot.wa.gov/Projects/i405/Springbrook/. Accessed on July 22, 2008.

Washington State Parks. 2008. Washington State Accessible Outdoor Recreation Guide – North Puget Sound Region. Available at: http://www.parks.wa.gov/ada-rec/detail.asp?region=NPS. Accessed on May 13, 2008.

MAPS

APPENDIX A

Reach Conditions, Unincorporated Lake Washington Shoreline (Reach K)

Table A-1. Lake Washington Shoreline Ecological Function Ratings

Shoreline	Light	LWD	Nitrogen	Pathogen	Phosphorus	Sediment	Toxins	Hydrology	Wave Energy
Reach K	2	1	3	4	2	3	2	2	2

1=Low; 2=Low-Medium; 3=Medium; 4=Medium-High; 5=High

Source: King County (2008).